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SCHOOL SCIENCE AND MATHEMATICS

VOL. XLII MARCH, 1942 WHOLE NO. 365

WHAT CAN THE SCHOOLS DO FOR AMERICA?

GLEN W. WARNER

In this nation of 130 million people nearly one-third are in the schools, hence the contribution of the schools to the war program should be proportionately great. Two programs are in simultaneous progress: one devoted to the solution of immediate problems, and one looking far into the future—the conflict in the months or years to come and the reconstruction of civilization after the conflict of fighting men and machines has ceased. Winning the war is of course the first concern of all, but it is scarcely less important than the establishment of proper conditions after the war. It is always correct for the schools to take a long-term outlook, but in times of emergency additional emphasis should be given to current needs.

To answer our question we must first know the needs. Every move on the war fronts emphasizes the necessity for better coordination and for more and better machines. The first of these must be and is being solved by our government officials in cooperation with those of our allies. The second is in the hands of our government and industry. The third, more effective machines for offence and defence, is largely our responsibility and opportunity. Better machines can be produced in quantity only after they are designed and perfected. This work requires individuals with ability to think, to imagine, to analyze, to do. Here, just as in some military and naval departments, we have failed to prepare. There is immediate need for a multitude of workers in all the fields of science. Here is what Dr. Henry A. Barton, Director of the American Institute of Physics, says:

The present emergency demands that every effort be made to increase the supply of personnel trained in the applications of the physical sciences. They will be called upon to put physics to work in the defense industries, in the civil service of the United States Government, and in the armed forces. Our country has been caught desperately short in the supply of such men because careers in physics have not been brought adequately to the attention of high school students.

Tens of thousand of such individuals are necessary now and many more will be called in the immediate future.

. . . . .

All boys and girls showing a natural aptitude for laboratory work and a reasonable skill in mathematics and physics should be given the opportunity to acquire as much physics instruction as possible. They will be of maximum usefulness if they have had at least two years of mathematics.

We are in particular need of the maximum number of people trained in the fundamentals of electricity. We ask you therefore to instruct all the vocational guidance officers to urge these youngsters to go on to college wherever this is financially possible, majoring in physics, mathematics, and engineering fundamentals. All radio amateurs in high schools should especially be urged to continue their education immediately after graduation, either by entering college or by taking appropriate courses at the nearest engineering defense training center. . . .

By a policy of chasing rainbows and of mushy education many semi-prepared and short-sighted educational leaders have led the schools to neglect fundamental education in the basic tool subjects. Now we are reaping the harvest of puny grain produced from such soil preparation and cultivation. We cannot eliminate the mistakes of the past but we can prevent repetition. How? First revise our school curricula to curtail non-essentials and give sufficient time for basic subjects properly presented. If teachers are not prepared for this work, demand that they prepare immediately by taking evening and Saturday courses.

It has also been shown that notwithstanding the phenomenal progress made in the health and medical sciences, vast numbers of our population are handicapped by preventable or curable physical ills. Malnutrition in a land of surplus food, often due to ignorance and neglect rather than to poverty and want; defective vision and hearing; diseased teeth; foot diseases and deformities; and many other defects brought about by neglect and improper clothing, are only a few of the many ills that should have the attention of our educational system. To correct these defects more emphasis should be given in our courses in science and health and immediate steps should be taken to educate the parents and the general public regarding these conditions and their improvement.

Finally there will now be added to the work of the schools

many other activities such as more attention to fire drills, air raid drills, collecting supplies, selling stamps, gardening, and a host of other essential and some questionable jobs. The important ones should be so conducted that they will create a minimum of interference with the basic work of the schools. There is no beating of drums for those engaged in the prosaic job of acquiring a working knowledge of the fundamentals of mathematics, neither is there for the crew of a submarine or airplane defending our shores, but both are essential for winning the war and maintaining peace after the war, and it is our job to teach young people to do a good job without applause.

A CALENDAR OF THE BIRTHDAYS OF SCIENTISTS FOR MARCH[1]

JAMES D. TELLER
College of Education, Ohio State University

Day	*Year*	*Name*	*Birthplace*	*Specialty*
1	1862	Edward Curtis Franklin	Geary City, Kansas	Chemist
2	1811	Hugh Edwin Strickland	Righton, Yorkshire, England	Naturalist
3	1847	*Alexander Graham Bell	Edinburgh, Scotland	Inventor
3	1800	Heinrich Georg Broun	Heidelberg, Germany	Geologist
3	1879	*Elmer Verner McCollum	Fort Scott, Kansas	Biochemist
3	1709	Andreas Sigiamund Marggraf	Berlin, Germany	Chemist
3	1841	Sir John Murray	Coburg, Ontario, Canada	Naturalist
5	1810	Jacob Bell	London, England	Chemist
5	1830	Sir Charles Wyville Thomson	Bonsyde, Linlithgowshire, Scotland	Naturalist
6	1787	*Joseph von Fraunhofer	Straubing Bavaria	Physicist
6	1847	Johannes Georg Hagen	Bregenz, Germany	Astronomer
6	1810	George Robert Waterhouse	Somer's Town, England	Naturalist
7	1849	*Luther Burbank	Lancaster, Massachusetts	Botanist
7	1869	Ernest Julius Cohen	Amsterdam, Holland	Chemist
7	1827	John Hall Gladstone	London, England	Chemist
7	1792	*Sir John Frederick William Herschel	Slough, Bucks, England	Astronomer
7	1839	Ludwig Mond	Cassel, Germany	Chemist
7	1746	André Michaux	Versailles, France	Botanist
7	1765	Joseph Nicephore Niepce	Châlon-sur-Saône, France	Physicist
8	1788	*Antoine César Becquerel	Châtillon sur Loing, France	Physicist
8	1836	*Sir Michael Foster	Huntingdon, England	Physiologist
9	1856	*Edward Goodrich Acheson	Washington, Pennsylvania	Inventor
9	1758	Franz Joseph Gall	Fiefenbrunn, Baden	Anatomist
10	1628	*Marcello Malpighi	Crevalcuore, Italy	Physiologist
11	1811	*Urbain Jean Joseph Leverrier	St. Lô, Normandy, France	Astronomer
11	1818	Étienne Henri Sainte-Claire Deville	St. Thomas, West Indies	Chemist
12	1790	*John Frederic Daniell	London, England	Physicist
12	1832	Charles Friedel	Strasbourg, France	Chemist
12	1824	*Gustav Robert Kirchhoff	Königsberg, Prussia	Physicist
12	1835	*Simon Newcomb	Wallace, Nova Scotia	Astronomer
12	1838	*Sir William Henry Perkin	London, England	Chemist
12	1812	Sir Joseph Prestwich	Clapham, Surrey, England	Geologist

Day	*Year*	*Name*	*Birthplace*	*Speciality*
13	1855	*Percival Lowell	Boston, Massachusetts	Astronomer
13	1733	*Joseph Priestley	Fieldhead, England	Chemist
14	1800	James Bogardus	Catskill, New York	Inventor
14	1854	*Paul Ehrlich[2]	Strehlen, Silesia	Medical Scientist
14	1879	*Albert Einstein	Ulm, Württemburg	Physicist
15	1858	Liberty Hyde Bailey	South Haven, Michigan	Botanist
15	1713	*Nicilas Louis de Lacaille	Rumigny, France	Astronomer
16	1750	Carolina Lucretia Herschel	Hanover, England	Astronomer
16	1853	Heinrich Gustav Johannes Kayser	Bingen on the Rhine, Germany	Physicist
16	1787	*Georg Simon Ohm	Erlangen, Germany	Physicist
19	1868	Charles Ernest Acker	Bourbon, Indiana	Inventor
19	1865	William Morton Wheeler	Milwaukee, Wisconsin	Zoologist
20	1735	Torbern Olof Bergman	Vestergötland, Sweden	Chemist
20	1814	John Goodsir	Anstruther, Fife, Scotland	Anatomist
22	1799	Friedrich Wilhelm August Argelander	Memel, Germany	Astronomer
22	1868	*Robert Andrews Millikan	Morrison, Illinois	Physicist
22	1785	Adam Sedgwick	Dent, Yorkshire, England	Geologist
23	1839	Julius Hann	Linz, Upper Austria	Meteorologist
23	1837	Richard Anthony Proctor	Chelsea, England	Astronomer
23	1769	*William Smith	Churchill in Oxfordshire, England	Geologist
24	1820	*Alexandre Edmond Becquerel	Paris, France	Physicist
24	1834	John Wesley Powell	Mount Morris, New York	Geologist
25	1786	Giovani Battista Amici	Modena, Italy	Astronomer
25	1848	William Keith Brooks	Cleveland, Ohio	Zoologist
25	1800	Heinrich von Dechen	Berlin, Germany	Botanist
25	1863	Simon Flexner	Louisville, Kentucky	Pathologist
26	1893	*James Bryant Conant	Boston, Massachusetts	Chemist
26	1817	Karl Wilhelm von Naegeli	Zürich, Switzerland	Botanist
26	1753	*Benjamin Thompson (Count Rumford)	Woburn, Massachusetts	Physicist
27	1855	Sir James Alfred Ewing	Dundee, Scotland	Physicist
27	1824	Johann Wilhelm Hittorf	Bonn, Germany	Physicist
27	1854	*Giovanni Battista Grassi	Rovellasca, Italy	Zoologist
27	1844	Adolphus Washington Greely	Newburyport, Massachusetts	Scientist
27	1845	*Wilhelm Konrad von Röntgen	Lennep, Germany	Physicist
28	1749	*Pierre Simon Laplace	Beaumont-en-Auge, France	Astronomer
29	1869	Ales Hrdlicka	Humpolec, Bohemia	Anthropologist
29	1840	Sir John Scott Keltie	Dundee, Scotland	Geographer
29	1853	*Elihu Thomson	Manchester, England	Inventor
30	1825	Theodor Kjerulf	Oslo, Norway	Geologist
31	1811	*Robert Wilhelm von Bunsen	Göttingen, Germany	Chemist
31	1777	Charles Cagniard de la Tour	Paris, France	Physicist
31	1801	Thomas Clark	Ayr, Scotland	Chemist
31	1596	*René Descartes	La Haye, Touraine, France	Philosopher of Science
31	1815	Jean Alphonse Favre	Geneva, Switzerland	Geologist
31	1870	Sir William Jackson Pope	London, England	Chemist
31	1850	Charles Doolittle Walcott	New York Mills, New York	Paleontologist

[1] All data are taken from *The Encyclopaedia Britannica*, 14th edition unless otherwise indicated.

For the uses and limitations of such a calendar, the reader is referred to the article which accompanies the calendar for October in SCHOOL SCIENCE AND MATHEMATICS, Vol. XLI, pp. 611–619, October, 1941. Calendars for the following months will be found in *Ibid.*, Vol. XLI, p. 768, November, 1941; *Ibid.*, Vol. XLI, pp. 884–885, December, 1941; *Ibid.*, Vol. XLII, pp. 87–88, January, 1942; *Ibid.*, Vol. XLII, pp. 187–188, February, 1942.

[2] Data for this entry are taken from *The Encyclopedia Americana*, 1939 edition.

* The starred names have been used by the writer in various bulletin board projects during the past twelve years.

WATCHING SPRING BIRDS

LAURA B. YOUNG
3115 North Capitol Avenue, Indianapolis, Indiana

[Editor's note. This is the second of a series of three articles about bird observation by Laura B. Young who is a writer of children's stories and verse primarily concerning nature study. The first article, "Watching Winter Birds" appeared in the January issue of SCHOOL SCIENCE AND MATHEMATICS. The third article, "Watching Summer Birds" will appear in the May issue.]

Birds in springtime are very alert and have quick movements. Their life has been a rather lonely life during the winter months, but when spring is on the way, Nature calls them to the responsibilities of mating and home building.

Oh, bird! as you soar in the heavens
With wings so free and light,
I wish that I might be with you,
As you go on your wondrous flight.
Would that I had wings to fly with you!
Perhaps then I should learn
The reason you leave us in autumn,
And in the springtime, return.

Often early migrants arrive during extremely cold weather. In most species, flocks of male birds return north a few weeks earlier than the females.

As they travel northward some birds leave the flock, choosing their future homes along the way, or instinctively going back to the localities where they were raised. Birds that have not migrated so far south may join the remaining members, thus making possible a wide distribution of bird life.

In studying bird migration, most ornithologists seem to agree that weather conditions and food supply are only contributing factors—that during the glacial periods their going away was definitely and necessarily established. As vegetation and animal life were pushed southward, these birds were forced to go. As the ice receded in the spring, bird life was again pressed northward, the birds hunting secluded, safer, and less crowded localities for breeding. In this way, it is said, a hereditary instinct was implanted.

More baffling, I believe, is the case of the permanent residents. Why they choose to stay here in the cold and snow, where food supply is limited, when in a short time they could be in the land of sunshine and warmth, where various kinds of foods are plentiful, is a question hard to answer.

During April and early May, here in the middle west, we see more birds than at any other time. Some remain, while others are transients, passing northward to their nesting places. Often the transients will stay for a day or two along the route where food and shelter are abundant.

Watching birds is very interesting. Each trip to the country, along a stream, to the swamp or deep woods, will unfold new and important observations, giving much pleasure and knowledge of bird activities.

In our own yards, especially if we have trees and bushes, a bird bath or feeding shelter, we see many birds, both old friends and new. In springtime birds become more shy, as they no longer depend on us for food and water. Children should be encouraged to make bird sanctuaries in their back yards.

Among our more common back-yard or doorstep birds are robins, thrushes, cardinals, wrens, catbirds, hummingbirds, mourning doves and, of course, sparrows, starlings, grackles, and blackbirds.

The actions of some birds, even of the same species, are different than others. Some are outstanding in personality, being bolder or more shy, as the case may be, or a little different from the others in habits.

Of all birds, it seems to me robins are the most like home folks. They want to be near people and to build under porch eaves and in near-by trees. The noise of children at play, or of cars passing back and forth, does not seem to disturb them.

Both robin parents-to-be work very hard at nest building, making a strong, substantial nest of rootlets, sticks, strings, paper, rags, grass, and many mouthfuls of mud. They sprinkle the mud in the nest, shaking their heads from side to side. The female then turns round and round inside the nest, shaping it to suit her body.

Once a pair of robins built in our Norway maple, and among other material they used quite a large piece of the comic paper strip in the nest. My children tried to make each other believe that the mother robin would show the pictures to her little ones.

It is said the robin has more than twenty-five different songs or calls. His evening song is so peaceful, like a sweet benediction to the world. His alarm call, when danger is near the nest, cannot be mistaken for any other sound. Sharp, continued shrieks quickly bring help from his bird neighbors.

The wood thrush is not as bold as the robin, but is a very

trusting bird. When close, he seems to look directly at one. The wood thrush usually builds in the deep woods, but occasionally he builds close to houses. His call is a sweet, whistling song. These birds can put up a terrific fight if their young are in danger. I once saw a pair drive off a large owl by flying into his face, beating him with their wings, and pecking at him.

The bluebird, like the robin, is a member of the thrush family. The bright blue plumage is a cheerful sight early in spring. Their food consists mostly of insects, and for this reason they should be encouraged to stay near. They are very gentle and unafraid. A hollow tree seems to be the favorite nesting place, but a wooden box put in a quiet place, not too high, will often attract a pair of bluebirds.

The cardinal is a friendly bird the year around. The flaming red plumage of the male becomes brighter still in springtime. His cheerful song during both winter and summer makes him a favorite among bird lovers. The female is much more subdued in coloring than the male. She does little singing, but with her "tsp tsp," as she picks up grain and cracks it with her strong beak, she makes her presence known. Cardinals build rather low in large bushes. We once had a pair that built in a syringa bush close to the driveway, where the car pushed against the bush morning and evening. The cardinals were not disturbed, but stayed on or close to the nest as the bush swayed.

Our ruby throat, which is the only hummingbird east of the Rocky Mountains, is a beautiful and interesting little fellow. To a casual observer he may seem rather evasive, with his quick, darting movements as he flies from flower to flower, but he really is fearless. Many times hummingbirds have visited our gladiolas while we were sitting on the back doorstep not a foot away. A tube of sweetened water suspended from the window or any place close will keep them near during spring and summer. The nest is very small and cup-shaped. It rests on a horizontal limb and is cleverly covered with lichens and bark, so that it almost looks like part of the limb itself.

One day as I strolled in my orchard,
With the drowsiness spring often brings,
I saw a gold flash, then a small, darting form,
Heard the whir of an oriole's wings.
That flash of gold, and the gold of the sun,
I always recall when an oriole sings,
And the thrill of that day, when I heard it in May—
The whir of an oriole's wings.

CHIMNEY SWIFTS

The home of the oriole is a strongly woven nest of grasses, weeds, and wood fibre, lined with hair. Sometimes a heavy string is woven in to give it strength. The female bird will hang on a branch head downward, weaving the nest with her beak. She is an excellent weaver, making a strong pocket-shaped nest hanging from a bough.

Orioles sing sweetly, and are of great benefit to everyone as they feed largely on hairy caterpillars which many other birds will not eat.

Last spring my son and I had an unusual experience. One noon we were driving on one of the principal streets, close to downtown, when suddenly we were engulfed by hundreds of birds. They were flying crazily all around us, never lighting, but swooping close enough to the ground for some to be struck by cars. Others were flying in large circles. They were chimney swifts that had been driven from one of the chimneys of a large old-fashioned house that was being torn down. Chimney swifts never alight except in a chimney or a hollow tree. This accounted for their wild flying, as they had no place to go.

These birds build in chimneys in the springtime. They fasten sticks together with their glue-like saliva, and then glue the nest to the inside of the chimney. Spines on the ends of the birds' tail feathers help them to stand upright.

House wrens are interesting to watch. They flit about, twittering, and looking first into one bird house, then another. Often after they apparently have decided on a house and start to build they change their minds. After much family talk they choose another to finally build the nest. The female is very patient, seldom leaving the eggs. The male bird carries her food, first perching on a near-by twig to await his chance to slip to the nest, as he thinks, unnoticed. When the hot afternoon sun would shine on the home of one of the little wren families in our yard, the mother-to-be would sit on the eggs and hang her head clear out of the wren house.

I went to the edge of the city today,
To visit the marshy ground,
For I knew that a friend and his relatives
On the rushes and reeds could be found.

'Twas snowy and cold, but he called to me,
His voice I plainly heard,
I knew that spring would soon be here—
He was the red-winged blackbird.

A trip to a swamp or any low, marshy ground, or to a body of water, is very fascinating to the Nature lover. Daybreak or just before dark is the best time for observation.

In swampy places red-winged blackbirds can be seen very early in springtime. The bright red and orange shoulders of the male and his shiny black coat make him a conspicuous figure in the sunshine.

Rails, coots, cranes, and herons are occasionally seen.

Wild Ducks

Wild ducks, stopping over early in the morning from their nocturnal migration flight, will circle the water two or three times, then finally settle in some low bushes or high grass. Before long they will slide easily into the water, dipping for frogs, lizards, small fish, and other animals.

Birds sometimes get lost from the flock during migration, or hunger may cause them to stop to feed or perhaps rest. For these reasons we often see strange birds that are really far away from their nesting site.

When a bird gets separated from his fellow travelers he usually wanders around a day or so, until more of his kind pass over. Then he has an opportunity to join the flock and continue the journey home.

ROOT HAIRS VIA THE TEST TUBE

JOSEPH W. RHODES
The Senior High School, Beloit, Wisconsin

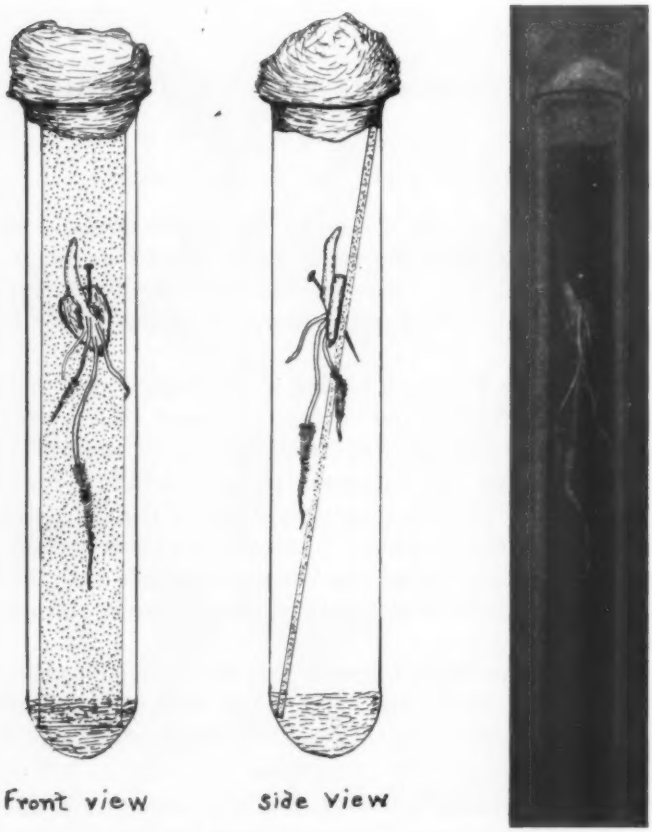
The growing of root hairs is one of the problems many biology teachers associate with the study of seeds and seedlings. The question often asked is, "How can root hairs be studied without being destroyed by air currents found in any normally heated room?"

Because it is a monocot having a relatively large 'seed' the common dent corn may be successfully used. The kernels are placed in a large towel-padded flower pot saucer for germinating. The moisture from the watersoaked paper towels is prevented from escaping by inverting another saucer of the same size over the corn. With the humidity relatively high the germination process is accelerated. Allow the kernels to remain in the covered saucer until both plumule and hypocotyl break through the outer covering.

In the meantime soaked kernels may be removed for the study of the monocot 'seed.' By cutting the kernels longitudinally through the embryo and then placing them in a weak iodine solution for a minute or two the endosperm (starch) will become colored making it easily identified. The plumule and hypocotyl are also more easily seen. If the sectioned kernels are rinsed, the water will wash off the excess iodine preventing any skin coloration in handling.

The test tubes are prepared by cutting strips of strawboard, pulpboard, or any medium heavy cardboard, so that they will easily slide into the test tubes. There should be $\frac{1}{16}$ to $\frac{1}{8}$ of an inch provision on either side of the strip for expansion when the strip becomes saturated. Any sized test tube may be used;

however, one that is about 25 mm. in diameter and 18 cm. in length has proved the most successful. As soon as the process of germination has become evident the kernels are removed from the saucer and pinned singly on the center of the cardboard strips. The pin should pierce the kernel at the side of the embryo, preventing any injury. The kernel is placed with the point-of-attachment downward to make possible the best seedling



Photograph and drawings showing root hair development.
Photograph, courtesy of Toge Johannson.

development. Each strip should be about one inch shorter than the test tube to provide room for a cotton plug. A one inch column of water is poured into the tube. If the root hair development is not satisfactory the cotton plugs may then be inserted.

The number of test tubes prepared should be determined by the size of the class, the experiments to be performed, etc.

The rate of seedling growth and root hair development can be determined by daily observation. Care, however, should be taken not to tip the tubes so that the water will come in contact with the root hairs, destroying them.

A tube can be placed on each laboratory table and held upright by placing in a quart mason jar or some similarly shaped container. It has been found advisable to use the cotton plugs when the tubes are used for class study. With the use of dissecting microscopes the root hairs can be readily studied. How does the tip of the root differ from the region in back of it? Where are the root hairs located? These and similar questions can be answered by observation.

The number of possible variations makes this apparatus particularly valuable. The effect of heat upon the seed germination can be clearly shown by placing one test tube in a cool place and another in a warm place, 85° to 90°F. with the third kept at room temperature. Differences in the rate of growth can be observed from careful study at regular intervals.

Another interesting variation may be observed by pinning a kernel on the cardboard with the plumule pointed downward. The 'curving' of both the plumule and hypocotyl in the next few days will clearly demonstrate geotropism. If desired a wider mouthed jar may be substituted to allow the continued turning of the kernel and the 'curving' of the root and stem.

By placing one tube in the dark at room temperature and the second on the window sill or some equally well-lighted place, the effect of light on seedlings may be easily seen. The one kept in a dark place will be of a yellowish color, showing the absence of chlorophyll. A greater stem growth will illustrate the plant's attempt to reach a source of light before the stored food reserve has been exhausted.

A careful examination of the seedlings allowed to remain in the laboratory will show several interesting facts. They will probably vary in development showing a difference in seed vitality.

Attention may also be drawn to the definite areas of lateral root origin. They are found most abundantly in the region immediately behind the area of root hair growth. They usually appear in vertical rows because their origin is restricted to regions opposite the xylem.

HAVE YOU TRIED CLAY?

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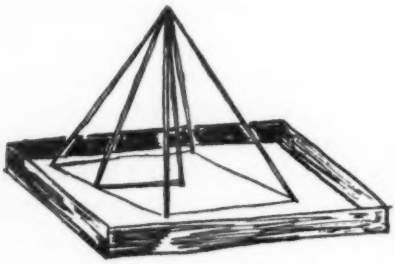
The title gives this story away. Just try clay. It molds itself to your purposes. Those of us who attempt to teach solid geometry find ourselves reaching about for anything that comes to hand to simplify the presentation of problems. We call for cardboard and slim balsa sticks when a line perpendicular to a plane is to be extended its length beyond the plane. We find that fine balsa put together with model airplane glue makes beautifully neat prisms, pyramids, and regular polyhedra. But give me a clay box or a clay covered sphere for swift and easy demonstration of miscellaneous problems. The average example can be set up almost as quickly as read. Then it is even more readily collapsed to make way for the next problem.



We use flat boxes. A hose box is excellent, with the cover placed underneath to strengthen the box. Into the box we press softened modeling clay to the thickness of half an inch or more. When the clay has been smoothed with the fingers, construction may begin. Dividers from an engineering set or compasses especially tampered with to have no pencil point but two sharp metal points are best. With these, actual constructions such as making perpendicular lines, bisecting angles, etc., are easily performed on the surface of the clay. A half dozen "pick up sticks" will complete the picture for almost any problem.

For example, we recently came to this interesting statement: The sum of the perpendiculars dropped to a plane from the vertices of a parallelogram lying outside the plane equals four times the length of the perpendicular to the plane from the intersection of the diagonals.

To demonstrate this: Cross two unequal sticks at their mid-

points to represent the diagonals. With a small wad of clay, fasten these together, with the same wad attaching them to a stick stuck perpendicularly into the clay. Let the plane of the crossed sticks be non-parallel to the clay surface. Put in perpendicular sticks from all four vertices of the parallelogram. The class now sees the center perpendicular as median of two different trapezoids and therefore equal to one-fourth the sum of the four uprights which are the bases of the trapezoids.

Again: If each side of the base of a regular quadrangular pyramid is 8 feet and the slant height is 10 feet, what is the altitude?

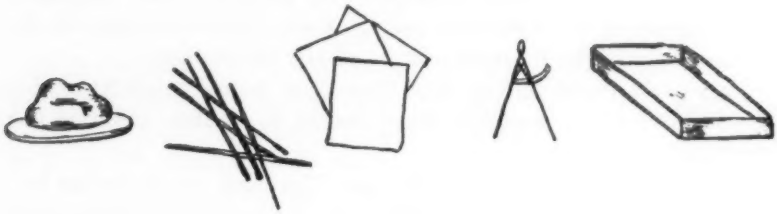
Draw the square base in the clay. Use pick up sticks for lateral edges, slant height, and altitude. A bit of clay will hold all the sticks together at the vertex. Probably no other medium quite so easily shows up the right triangles involved in the solution of this simple problem.

We find it convenient to use several of these clay boxes in the classroom. A few boys and girls have their own for study at home.

When the geometry turns spherical, some helpful boy who hasn't forgotten the joys of mud pie days is only too glad to soften the clay from a clay box with a few minutes' kneading. He flattens it out thin, and spreads it evenly on the surface of a globular glass bowl. Our bowl is the kind that has a rubber base and was made to hold flowers immersed in water. Our compasses for drawing great circles need not only to have both

points metal. We must also bend one of the legs so that the instrument reaches just a quadrant's distance on the sphere.

An excellent demonstration may then be given of such a theorem as: If one spherical triangle is the polar of a second, the second is also the polar of the first.



It may be that other teachers have chanced upon this use of clay in solid geometry. Whether this is the case or not, teachers of mathematics much prefer puzzling out their own trade tricks to being handed out solutions. We therefore leave you the clay to putter with as you please.

NEW LENS FOCUSES AUTOMATICALLY

Although the living eye, with its elastic lens, automatically focuses objects at varying distances, optical engineers have looked askance at many ingenious proposals to accomplsih this purpose in a photographic lens. But a four-element motion picture lens has now been designed by Bausch & Lomb in which one double-concave element is electronically oscillated on its axis by means of a special cell mounting developed by P. Stanley Smith, a New York radio engineer.

The new lens is confined to a distance of three-tenths of a millimeter in its axis movement but the oscillations are at the rate of 23,200 times per minute, thus continuously altering the focus so that all objects are uniformly in register from four feet to infinity, Although all objects are slightly softer in focus than with lenses of a fixed focal length, many photographers regard this as an improvement.

Smith, following the work of Dr. Ludwig Dieterich, an Austrian-born engineer, who patented a mechanical method for vibrating a lens element, designed an electronic method of achieving this purpose and has successfully incorporated the lens in a motion picture camera which it is believed will offer great flexibility in motion picture photography and direction.

At present action must be kept mobile within the set focus of the camera. Actors must work within a chalk line necessitated by the focal range of the camera. Lighting must be rearranged for each new focus, cameras reset, and distances taped.

The new electroplane camera, with a lens which keeps all moving objects in perpetual focus, holds the promise of a solution to one of the chief limitations in motion picture photography.

Bausch & Lomb engineers stated emphatically that the new oscillating lens could not be incorporated in hand cameras.

PREPARATION AND PROPERTIES OF BORON

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From the macroscopic standpoint, two types of elemental boron may be recognized, massive, and so-called "amorphous" boron. Massive or crystalline boron is a hard, black material which may appear crystalline or glassy. This type of boron is not to be confused with the aluminum boride AlB_{12} which has erroneously been called "crystalline boron." Massive boron can be obtained in the pure state, whereas "amorphous" boron contains variable amounts of impurities depending upon the method of preparation and the subsequent methods of purification. "Amorphous" boron is generally made by a thermite reaction and is usually obtained as a very fine, dark-colored powder. However, this material is not entirely amorphous since X-ray analysis has shown that a small part of the material is similar to crystalline boron while the major portion of the material is a glassy, or truly amorphous substance.

CRYSTALLINE BORON

Crystalline or massive boron is prepared by two general methods. In the first method, reduction or thermal decomposition of the boron halides gives a product containing 98 to 99.9 per cent boron. Weintraub[1] was the first to develop the technique of preparing pure boron in connection with a search for materials which might be used as incandescent lamp filaments. A mixture of gaseous boron trichloride and hydrogen is passed between the electrodes of a high voltage alternating current arc giving hydrogen chloride and pure boron which deposits on the cooled electrodes. Gaseous boron tribromide may be decomposed thermally on electrically heated wires of iron, tungsten, or preferably tantalum. The boron deposits on the heated wire from which it may be easily removed.

The second method for obtaining pure boron consists of fusing impure "amorphous" boron in an arc. Since the melting point of boron is rather high (about 2,500°C.), the impurities present are volatilized leaving pure, fused boron.

[1] Weintraub, E. "Preparation and Properties of Pure Boron," *Transactions of the American Electrochemical Society, 16*, pp. 165–184, 1909.

"Amorphous" Boron

The thermite reaction between magnesium powder and boron trioxide gives "amorphous" boron, but impure products are always obtained. The amount of impurity may range from 5 to 70 per cent. In spite of this, the thermite reaction is the most convenient method for the preparation of boron since moderate amounts of impurity do not seriously interfere with most of its uses. The method consists of igniting an intimate mixture of powdered magnesium and dry boron trioxide in an iron crucible. A vigorous reaction occurs and a mass of gray coke-like clinkers is formed. These clinkers contain boron, some unreacted magnesium and boron trioxide, magnesium oxide and magnesium boride, as well as combined oxygen and nitrogen (if the reaction is carried out in the presence of air). The clinkers are digested with an excess of dilute sulfuric acid and the insoluble boron is filtered off, washed, and dried. The final product contains boron, magnesium, and usually oxygen. For a long time, it was not considered possible to obtain a product free from oxygen, but recent work at Syracuse University has shown that this is not true. If atmospheric gases are excluded during the thermite reaction and the condition of the reactants is carefully controlled, a product analyzing 87 to 90 per cent boron and 10 to 13 per cent magnesium can be obtained. Otherwise the product contains less boron, more or less magnesium, and oxygen.

Numerous attempts have been made to purify "amorphous" boron, but only a few are worthy of mention. Fusion in an arc to give pure massive boron has already been mentioned. Fusion with boron trioxide increases the boron content 1 to 2 per cent. Recent work by the author[2] at Syracuse University has shown that the treatment of "amorphous" boron with hydrogen chloride gas at temperaturers near 550°C. gives the purest "amorphous" boron analyzing about 96 per cent of the element. If the boron to be purified contains only boron and magnesium, for example 89 per cent boron and 11 per cent magnesium, the magnesium content is gradually lowered by the hydrogen chloride treatment until the boron content reaches a maximum. Further treatment with hydrogen chloride decreases the boron content; the magnesium content is reduced to less than half a per cent, the magnesium and boron being largely replaced by chlorine.

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[2] Kremers, Howard E. "Preparation and Properties of Boron," *Thesis*, Syracuse University, June, 1941.

If the original boron contains oxygen, the same effect is observed, the oxygen being replaced gradually by chlorine.

Much has been written concerning the ultimate composition of "amorphous" boron, but the question of its composition is still a subject of discussion. It was thought that the material prepared by the thermite reaction between magnesium and boron trioxide consisted largely of a so-called boron suboxide corresponding to the formulas B_7O and B_3O. However, there is no conclusive evidence for the existence of these suboxides. It is probable that "amorphous" boron is a solid solution containing truly amorphous boron, crystalline boron, and impurities in the form of borides, and oxides if oxygen is present.

Properties of Boron

Pure boron is the hardest element after carbon (diamond). It is interesting to note that boron carbide (B_4C) is assigned a hardness next to diamond and is followed by boron. Boron is considered to have approximately the same hardness as carborundum. Although the melting point of boron is quite high, about 2,500°C., it sublimes somewhat before its melting point is reached; however, it can be melted easily in a vacuum. Boron is one of the few elements whose crystal habit is not known.

Chemically, boron is rather inert at room temperature and is insoluble in most acids and bases with the exception of nitric acid and aqua regia which attack it vigorously forming boric acid. At elevated temperatures it combines directly with oxygen with the liberation of much heat, and at temperatures near its melting point it reacts with nearly all known refractory materials and oxides. However, it is inert toward boron carbide and may be fused in crucibles made of this material.

The electrical properties[3] of boron are perhaps most outstanding. At room temperature boron is a very poor conductor of electricity. The resistance of pure fused boron is about a thousand billion times (10^{12}) that of copper. However, if the temperature of the boron is raised, the resistance decreases; in general, for temperatures below a red heat, the resistance of boron decreases by one-half for every 16 degrees rise in temperature. Consequently, at high temperatures boron is a good conductor of electricity. Metals generally have a positive temperature coefficient of resistance, that is, the resistance increases as the tem-

[3] Weintraub, E. "The Properties and Preparation of the Element Boron," *Journal of Industrial and Engineering Chemistry*, *3*, pp. 299–301, May, 1911; *ibid.*, *5*, 106–115, February, 1913.

perature is raised; boron, on the other hand has a negative temperature coefficient of resistance and the resistance decreases with rise in temperature. If boron is compared with silicon and carbon in regard to electrical characteristics, there is some resemblance. For carbon, the ratio of the resistance at 0°C. to the resistance at a red heat is equal to about 2; for silicon this ratio is about 100, and for boron it is about 1,000,000; all three show a negative temperature coefficient of resistance. If small amounts of carbon are dissolved in boron, the resulting solid solution behaves like carbon in its electrical characteristics.

Uses of Boron

The electrical properties of boron immediately suggest its use in temperature controlling devices. But this application and the other possible applications of boron are limited (1) because it is difficult to secure good electrical contact with the boron and (2) because it is expensive to prepare the pure element.

On account of its extreme hardness, boron may be used as an abrasive, but boron carbide and carborundum are more readily available and are much less expensive.

"Amorphous" boron can be produced more cheaply than massive boron and is therefore more adaptable for practical uses. Boron has been used to deoxidize copper for electrical purposes. Ferrous metals may be surface-hardened by coating with boron and then subjecting the materials so treated to a case-hardening heat treatment. The addition of very small quantities of boron to manganese steel produces a metal product which is claimed to have tremendous impact resistance and hence may be used for armor plate.

STANDARDS FOR CONTRACEPTIVES

The American Medical Association is urged to set up standards for contraceptives, as it already has for drugs and foods, in a report on three birth-control clinics in New York, Cincinnati and Spartanburg, N. C., by Dr. Regine K. Stix, of New York. The study, financed by the Milbank Memorial Fund, is reported in the *A.M.A. Journal*.

Patients at the clinics were largely women whose health would be injured by child-bearing. The study convinced Dr. Stix that a standard set by the Association after proper study would do much "to improve the quality of commercial contraceptives."

Dr. Stix asserted that "wise pressure" on makers of contraceptives would help to reduce prices to a point where many people in the poorer sections of the country could afford them. These families, it was pointed out, are least able to bear the cost of raising and educating children.

RESPONSIBILITIES OF SCIENTISTS AND TEACHERS OF SCIENCE*

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Suggestions for discussion, if they are to have any force, should embody no obscure or ambiguous terminology. In order to avoid all possibility of misunderstanding or misinterpretation, we shall begin by clarifying our basic terms. In modern usage the term *science*, or, more specifically, *natural science*, includes the physical and the biological sciences. This branch of knowledge, natural science, was formerly included in natural philosophy. It is not strange that philosophy should have included these branches of study because, philosophy, in its etymological sense, is the love, study, and pursuit of wisdom; it is nothing more than accurate knowledge of things in their causes, whether theoretical or practical.

The term philosophy, of course, is now sometimes loosely applied to the rules or principles by which an individual lives, when it is referred to as his "philosophy of life." The present thesis is concerned with philosophy in the strict and true sense of the term as the knowledge of things in their causes.

In the broad sense of the term, *science*, literally, knowledge, is all knowledge which is acquired by study; but in modern use the term science has become synonymous with what was formerly qualified as inductive *physical* science; this restricts it to the knowledge of the phenomena of the material universe and its laws. That is to say, in the present generation, science means experimentation and observation; for the scholar of the Middle Ages, it meant knowledge.

The number of fundamental sciences and their mutual interdependence is also an important distinction to make at the outset. Every science, as you know, is founded on abstraction. According to the degree of abstraction, the range is in the following order: physics, mathematics, and metaphysics. Physics, according to the literal meaning of the word, is concerned with a study of natural phenomena and includes, in our present appellation, astronomy, geology, physics, chemistry, biology and all of their allied and sub-sciences. Physical science is an experi-

* Read before the Junior College Group of the Central Association of Science and Mathematics Teachers, Nov. 22, 1941.

mental study of natural phenomena and is concerned with secondary causes only, not the ultimate or primary causes.

It is most important and necessary in the study of physical science to use theories; but as Professor Basile J. Luyet has pointed out in "The Case Against the Cell Theory" (*Science*, March 15, 1940), theories are dangerous tools which should be put into the hands of those only who know enough never to believe in them. The science of thinking consists in knowing how to use the theories only as tools and never to admit any theory except as a possibility.

The Scholastic doctrine of conceptual knowledge may be summed up as follows: Conceptual knowledge is not produced in an independent fashion by activity of the mind nor furnished wholly by data of the senses; it results from an intellectual purification of the sensible data by an intellectual act which is called *abstraction*. In other words, abstraction may be defined as the link between what is purely sensible and that which is purely intelligible.

The great truths of knowledge do not depend *in principle* upon the findings of the empirical, that is, the experimental sciences; neither are they proved nor disproved by them. These great truths, these universal truths, being truths, remain unchanged. All normal people at all times distinguish certain fundamental principles, axiomatic truths, and verities, such as: existence differs from non-existence; every effect has an adequate cause; the principle of contradiction; the principle of identity, etc. Knowledge of facts changes but the principles by which these facts are interpreted do not change. Like the principles of justice which, despite the mutability of governmental theories and practice throughout the history of the world remain unchanged, universal principles and truths are immutable. The same is true with all right metaphysical principles. For example, Aristotles's metaphysical principles in philosophy, like those of St. Thomas Aquinas in the thirteenth century, were not affected by some of their naïve biological theories any more than the multiplication table was affected by them.

One must avoid confusing the *scientific method* with the *philosophy of science* as some have done. These have elaborated scientific methods into philosophical theories and have thus drawn erroneous and unwarranted conclusions.

Modern scientists have overwhelmingly increased the facts and have greatly improved the methods of discovering and in-

vestigating the phenomena of the physical universe; but this advance in experimentation, etc. has far surpassed their philosophical theories or interpretation of the newly discovered facts. By interpretation we mean in terms of universal truths. This is our great difficulty now.

There are three possible theories of the philosophy of science: the *physical* theory, the *mathematical* theory, and the *metaphysical* theory. The physical theory limits the explanation of the universe to empirical facts, that is, facts learned from experimentation and observation; the mathematical theory attempts to explain scientific facts and findings in the light of mathematics; the metaphysical theory (what Aristotle and the scholars of the Middle Ages called the *philosophy of nature*) explains the data of experimentation in the light of universal principles. The third theory is neglected by the majority of modern scientists today because of their lack of the knowledge of metaphysics. Thus it is seen that there is a distinction between the *scientific method* and the *philosophy of science*. The *scientific method* is concerned with the technique of investigation and seeks to *describe* natural phenomena; the *philosophy of science* seeks to *explain* these phenomena in terms of the intelligible. As methods of science, both the physical and mathematical procedures are sound; but as theories of the philosophy of science they are definitely unsound; because the first limits knowledge to physical phenomena alone and the second limits it to the mathematical interpretation of these phenomena. Metaphysics deals with the laws of being and must be considered and not contradicted when we are interpreting facts about a physical or chemical or any non-living or living being in our physical sciences. In order to elucidate our point here, we quote from Dr. Fulton J. Sheen, *Philosophy of Science*, who says: "The sciences (*meaning physical sciences*)[1] are valid in their own sphere, but not to the whole of knowledge; they are good as far as they go, but they do not go everywhere. The philosopher who knows the method and content and principles of his science will therefore not become excited when a new physical theory is offered to the world. Hence, we have little sympathy for those philosophers who, forgetting the principles which gave them certitude within their field, feel that the Quantum Theory proves free will, or that there is a God because the physics of Eddington and Jeans say there is a God,

[1] Parenthetical insert, ours.

The Quantum Theory has nothing more to do with the proof of free will than a proton has to do with a wish to be moral. The existence of God did not wait for Eddington and Jeans, and those fundamentalists who enthused about science becoming theistic are very apt to find their theism overthrown when the theories of these two notable scientists are upset. The life of a physical theory today has only about the life of a peace treaty. . . .

"The Quantum Theory, which deals with atomic jumps, has nothing to do with voluntary 'jumps' or resolutions, neither has mathematical physics anything to do with God. Jeans believes that because geometry applies to the world, therefore, God is a mathematician. When Eddington delivered an international broadcast on the atom, journalists headlined 'Day of Materialism Over.' Immediately science was hailed as giving support to God, but the philosopher whose God has no more support than the idealist theory of Eddington and Jeans will very soon find himself without a Creator. It is not often that Bertrand Russell can be quoted with approval, but in his *Scientific Outlook*, he properly anathematizes this spirit of philosophy which looks to science for all the proof of all its theses. He shows that 'Eddington deduces religion from the fact that atoms do not obey the laws of mathematics, and Jeans deduces it from the fact that they do'."[2]

Eddington and Jeans rank both as scientists and philosophers. Opposed to their conflicting and altogether chaotic mental acrobatics, these lines of Alfred Noyes, poet and philosopher, give evidence of intellectual balance and make sense. The poet says:[3]

"This universe
Exists, and by that one impossible fact
Declares itself a miracle; postulates
An infinite Power within itself, a Whole
Greater than any part, a Unity
Implying every attribute of God.
But men still trace the greater to the less,
Account for soul with flesh and dreams with dust,
Forgetting in their manifold world the One,
In whom for every splendour shining here
Abides an equal power behind the veil.
Was the eye contrived by blindly moving atoms,
Or the still-listening ear fulfilled with music
By forces without knowledge of sweet sounds?"

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[2] Fulton J. Sheen, *Philosophy of Science*, pp. 182, 183. Bruce ,1934.
[3] From *Watchers of the Sky*, by Alfred Noyes, Stokes, 1922.

Some seem to think that because the knowledge of scientific facts has advanced and changed, metaphysical principles are not applicable to them or, in other words, they seem to think that with the rise of every theory or fact of physical science, some immutable principle, some universal truth is thus out-moded. The assumption is that as science changes it clothes, metaphysics must change its complexion.

The assertion has often been made that the Scholastics were opposed to the empirical method. This erroneous statement is due to the mental inability of those who made these assertions —their inability to grasp the idea of the Scholastic *philosophy of science.* Facts at the present time are different from those of Aristotle's time or the days of St. Thomas Aquinas; but the metaphysical principles by which these facts are interpreted remain unchanged. Nevertheless, outside of Scholastic philosophy, unfortunately, there are at the present time a multitude of opinions and theories of philosophy; these represent about as many schools of thought as there are outstanding personages who rank as professional philosophers. Their dissensions, disagreements, and the lack of certitude and stability of their doctrines may well be considered one of the reasons why metaphysics, thus represented, has been lost to natural science. On the other hand, there are at the moment a number of influential scholars who are beginning to see the light. Typical of this situation is the following quotation from Dean Inge in *God and the Astronomers:* "For I am convinced that the classical tradition of Christian philosophy, which Roman Catholic scholars call the *philosophia perennis*, the perennial philosophy, is not merely the only possible Christian philosophy, but is the only system which will be found ultimately satisfying."

Because of the abandonment of metaphysics, the physical theory of the philosophy of science has been glorified. At present modern scientists hold that all knowledge is impossible beyond the empirical, that is, the experimental; for these, physical science is philosophy. This theory is contrary to the truth; it is a philosophical error, and scientifically considered, it is sheer nonsense; for something non-factual must interpret the facts.

The scientist, like every other human being, welcomes facts which seem to confirm preconceived ideas; he is also sometimes quite capable of evading or even suppressing facts which upset his cherished theory. It has been known in science that the subjective plays so dominant a part as to cause the experimenter to

see things which were not to be seen, because he thought he should see them. The experimental scientist, therefore, consciously or unconsciously, not only accepts the experience of others but he sometimes applies his own erratic philosophy, as well as that of others, to the interpretation of his scientific findings. Too often conclusions are based upon unsound reasoning, whether of the experimenter himself or that of the one he follows or upon interpretations made by some other so-called philosopher. There is no denying the bald fact that assertions which outstrip the evidence are all too numerous among scientists.

Everyone is a philosopher, either with or without a definite or true method; hence the common expression "points of view." These "points of view" are often substituted for sound philosophy; thus appearance is offered for reality; vagueness for clarity, and error for truth.

The study of the physical sciences by what is designated as the scientific method is relatively new. The marvelous and rapid advance of modern science and its almost innumerable accomplishments which are highly beneficial to humanity are astounding. This great progress in experimental science is due primarily to improvements in technologies. Our instruments and other facilities are better than those of the ancients; but it is very doubtful that our reasoning about the facts they reveal is any better. In order to be fair to modern scientific progress it is as unnecessary as it is unjust and disastrous to ignore ancient wisdom. Common sense, or the mind's possession of the laws of being, is the same today, yesterday, and always; but it does seem that in these modern times common sense is becoming increasingly uncommon.

The scientist working smugly in his laboratory where only weight and size and color and physical energy and power can be measured and estimated, sometimes tends to think of the immeasurable, the infinite, the eternal, either as non-existent or only as subjective figments or abstractions conjured up in lesser minds which have need of these. This high priest of science is self-sufficient and self-satisfied. He cannot by his methods weigh, measure, or test such human attributes and virtues as justice, faith, love, and goodness; therefore he deludes himself into thinking that these do not exist as realities. These "human values," as he calls them, these human attributes and virtues, are what they really are because of man's spiritual nature and

relation to his Creator. A right code of ethics cannot be deduced from experimental data any more than a particular grouping of cerebral atoms will of themselves bring one to accept and to respect the Golden Rule.

In surveying the more recent literature from the pens of various writers, mostly scientific men, more and more apparent is a notable evidence of alarm and confusion. This is because of the diabolical purposes which the inventions of modern science have been made to serve and the helplessness of scientists themselves to check the ravages which abuse of scientific instruments, inventions, and discoveries have wrought. There is a noticeable evidence too of a kind of groping, a searching—a pleading for some kind of fundamental truth—for something higher and nobler than mere material things—something which will stem the tide of havoc caused by a materialistic and Godless philosophy. Although it is the mental fashion at the present time to ignore or oppose the supernatural, this quest, this reaching out for what are expressed as "human values" seems to be an attempt to admit the supernatural at least through the back door.

What has been the role, what is the responsibility of modern science in this chaotic situation, this apparently hopeless muddle into which the greater part of the civilized world is now plunged? Physical science itself is in nowise directly responsible for it. The numerous and magnificent contributions of experimental science are all good in themselves. Modern science with its many advances and its great achievements is something to be admired, something to be encouraged, applauded and rightly used; it is, however, not something to be worshipped and adored.

It cannot be denied that the modern scientist has too often made a god of his speciality. His idol, unfortunately, is neither respected nor revered by the many who employ it to serve their own perverse ends. Science, as such, has no morality—no code of right or wrong. The man-at-large may use it as he chooses—for good or for evil, for weal or for woe.

The scientist as such is not responsible for the abuse of his well-ordered intentions, his patient, purposive, and persevering efforts; but if he holds the key to knowledge and power and might which are convertible into instruments of warfare, of blood, of carnage, and of human slaughter, he may not be indifferent to the abuse of his accomplishments. As a scientist, he has no obligations, no responsibilities; but as an ethical and moral being, as a man, he is bound to do something about it.

Like every other man the scientist is a human being; not because he is a higher vertebrate but because he is a rational creature endowed with human prerogatives—an immortal soul, an innate respect for the natural law, a perception of right and wrong, and a freedom to choose. To neglect these higher, these human faculties, and to ignore his potentialities is a responsibility which no human being can escape. Of course, the modern, materialistic scientist has not the time to find out exactly what manner of being he really is, he spends so much time trying to discover what he was! In this respect he might well be compared to the hypothetical, comic bird called "Floogie boo" which is reputed to fly backwards. Now, this imaginative bird, this "Floogie boo" flies backwards because he is not at all concerned about where he is going, he is so anxious to see whence he has come!

Pascal summarized this situation in the following words: "It is dangerous to show man in how many respects he resembles the inferior animals, without pointing out his grandeur. It is also dangerous to direct his attention to his grandeur without keeping him aware of his degradation. It is still more dangerous to leave him ignorant of both."

The average scientist is a just, honorable and upright man; insofar as his virtues go, he lives by Christian principles although he often does not profess Christ. The motives of his righteousness are apparently purely natural; because of his natural gifts and powers, the scientist lives by the natural law and according to his own interpretation of it; or, if he is more superficial, his justification is due to his high regard for respectability or for his pragmatic policies. Any of these motives may prompt him to live a life which will command the respect of his fellow men. And if he is a learned, eminent scientist, the common man holds him in high regard.

Neither does the integrity of the ordinary scientist suffer any severe test. Professionally, he is not obliged to deal with values; he is not called upon to be a judge in social or moral issues. Financially, there is generally for the scientist a certain modest security—whether he is engaged in research exclusively, or whether he is in the educational field, or perhaps a combination of the two. His associates in his professional and social life are usually men like himself, and, so, in a measure, the typical scientist, representing a small minority, lives apart from the world of trial, of tumult, and of turmoil.

The motives which prompt the virtues of the atheistic, of agnostic scientist make small appeal to the vast army of citizens, though the latter may be greatly impressed by the superior knowledge and power of the great scientific savant who appears to them as a kind of superman. This is precisely where the modern scientist becomes a stumbling block to the great mass of common humanity. The scientist cannot evade this, his most serious social responsibility.

There seem to be many scientists who realize the need of some form of religious experience in modern life but who fail to give to religion that preeminence over science which it deserves. Their loyalty to science, their natural god, leads them to an apparent conviction that there is an irreconcilability between science and religion. The scientific agnostic denies that there can be any certitude about the supernatural simply because its existence cannot be tested or proved by his, the experimental method. He forgets, however, that by the same method he certainly cannot prove the non-existence of the supernatural; and he unconsciously denies the validity of all supra-sense knowledge such as logic, setting himself up as the final word in knowledge.

This is the type of scientist who proposes an hypothesis, or a theory, and then marshals all of the possible evidence to buttress his postulate. This, of course, is what he should do; but it is not all that he should do. For he seems to forget that there are two sides to a balance and thus completely overlooks and ignores the counter evidence where his proposition is concerned. By some strange quirk in the mind of this type of modern scientist, he seems to think that nothing is reasonable but experimental science; this is his dogma. This unreasonable fear and dread of all things supernatural or religious dominates his very soul.

The reciprocal fear or dread of experimental science, however, is not to be found in the true philosopher or the theologian, for he realizes that there is no contradiction between philosophy, theology, and physical science since all are based upon truth and truth is one. On this point Pope Pius X sounded the dominant note when he said "Religion has no fear of science. Christianity does not tremble before discussion, but before ignorance."

Most natural scientists fail to take cognizance of the fact that theology is a science and, like philosophy and every other science has a rigorous method and a vocabulary peculiar to itself. Many

more or less ordinary words are common to the terminology of the various sciences; but their connotations often vary almost as black from white depending, for example, upon whether the word is employed by the scientist or the philosopher. It would therefore be amusing were it not so tragic at times to note the erroneous interpretations of these terms by specialists who presume to use them out of their respective fields.

The truly great scholar is humble. Long ago St. Augustine described the way to wisdom as, first, humility, secondly, humility, and thirdly, humility. Later, the great Louis Pasteur in one of the most trying experiences of his life humbly prayed: "God grant that by persevering labors I may bring a little stone to the frail ill-assured edifice of our knowledge of these deep mysteries of life and death where all our intellects have lamentably failed."

It is fitting that this truly great man of science should have this inscription over his tomb in the Pasteur Institute in Paris: "Happy is he who carries a God within him, an ideal of beauty to which he is obedient, an ideal of art, an ideal of science, an ideal of the Fatherland, an ideal of the virtues of the Gospel."

The physical scientist in his attempts to wrest from nature some of her mysteries finds that one victory is only a challenge to the solution of new problems before unrealized. Thus it is that science multiplies mysteries and the more we learn, the more convinced we are of our abysmal ignorance. So far as the natural scientist goes, there are relatively few of the phenomena of nature about which he can give a full or even a satisfactory explanation. Human knowledge at best is limited and always will be so. However much the frontiers of the sciences are expanded or may in the future be extended, just in the same proportion will the vast unknown increase in magnitude.

We have seen that the modern scientist is too often inclined to overestimate the efficacy and virtues of his method, and he is often very inconsistent in the use of it himself. An example of this exaggerated optimism is seen in a quotation from the writings of one of our most eminent scientists, a relatively short time ago. He said: "If our public schools, through which now pass the whole of the oncoming generation, could only get the objective scientific technique started, we could change in one generation the whole history of the United States and banish the terrible fears which are rife among all classes of our citizens as to the future of democracy."

We use this quotation anonymously and without any intention of humiliating the original author. What scientific method, what kind of experiment, or what feat of logic, brought him to such a conclusion, is difficult to conjecture. Unless I am laboring under a sad delusion, I believe it takes a good deal of "objective scientific technique" to throw a bomb from a dirigible. I am also under the impression that some of the worst crimes are perpetrated by very refined applications of scientific methods.

No doubt, at the time of its publication the statement quoted above drew a pitying smile from all of those who had made an adequate study of the subjects involved. Our purpose here is to point out that such rash generalizations, such manifestations of frenzied enthusiasm have done much harm—not only to the cause of science and its methods, but also to the cause of truth. For these overzealous, lop-sided men of science, it sometimes takes but a short time, if a very severe test, to disprove their faulty judgments and overhasty exaggerations.

As a contrast with the example of extreme and unwarranted optimism concerning the potency of science as a safequard of democracy, we quote from an article entitled "The Conscience of the Past and the Practice of the Present" which appeared in *Science*, August 25, 1939. This brief sketch includes a quotation from Father Francesco Lana (1631–1687). It may be surprising that at this early date, this inventor of the first airship, after enumerating the six technical objections which he foresaw to his invention, went on to say: "Other difficulties I see not, which may be objected against this Invention, besides one which to me seems greater than all the rest, and that is, That it may be thought that God will never suffer this Invention to take effect, because of the many consequences which may disturb the Civil Government of men. For who sees not, that no City can be secure against attack, since our Ship may at any time be placed directly over it, and descending down may discharge Souldiers; the same would happen to private Houses, and Ships on the Sea: for our Ship descending out of the Air to the sails of Sea-Ships, it may cut their Ropes, yea without descending by casting Grapples it may over-set them, kill their men, burn their Ships by artificial Fireworks and Fire-balls. And this they may do not only to Ships but to great Buildings, Castles, Cities, with such security that they which cast these things down from a height out of Gun-shot, cannot on the other side be offended by those below."

This early concept and understanding of aircraft and the prediction of modern methods of warfare may be a little surprising. But to one who has a real understanding of human nature as it often asserts itself in those who have no sound or sincere religious convictions, there is nothing so amazing at least in this part of the quotation. A right standard of morality is not established according to scientific formulae; neither will the most diligent search for truth and the best habits of scientific thinking of themselves promote the practice of the virtues of justice, temperance, charity or any other virtue. The whole difficulty arises from the refusal of scientific specialists to admit the validity of knowledge in other fields than their own, in fields which they have not explored and about which they have no understanding. This is a kind of narrow-mindedness which amounts to nothing less than intellectual pride. It is the kind of thing that the witty Irishman summed up very tersely when he said: "A man is usually down on a thing that he isn't up on."

At this point we quote from Mortimer Adler under the title *The Chicago School* . . . "just as Harper's Chicago reflected and formulated the 'religion of science' which dominated American culture from the nineties to the thirties, so Hutchins' Chicago, in the past ten years has focused attention upon—more than that, has become the leading forum for—the crucial issue of our day; *whether science is enough theoretically or practically;* whether a culture can be healthy, whether democracy can be defended if theology and metaphysics, ethics and politics are either despised or, what is the same, degraded to topics about which laboratory scientists pontificate after they have won the Nobel Prize or are called to the Gifford Lectureship . . . Hutchins' aim was synthesis—to relate science, philosophy, and theology harmoniously without sacrificing the autonomy of each . . . It was not merely the University that Hutchins sought to reform. He wished to free American education and culture from the negations and provincialism which Chicago typified."

What we have said concerning the responsibilities of the scientist applies to the savant, the man of research, in a word, to the professional scientist; neither do we intend to bracket all scientists as atheists or agnostics. Likewise we do not wish to give the impression that we think a good scientist must also be a metaphysician. The true scientist is fortunate if he carries on his work with an appreciable knowledge of logic and an unperverted natural understanding of the laws of being and thought,

and is sufficiently aware of his limits to stick to his last. Such a scientist will be immune to the influence of erroneous metaphysics and pseudoscience; his common sense or natural metaphysics, while serving him well as a scientist, will leave all purely metaphysical problems to the professionals whose specialty these are.

If the teacher of science is personally unequipped to meet the challenge of the inquiring student in other fields of knowledge, he should be honest enough to refer the inquirer to the proper source of information. For example, the teachers of biology, geology, chemistry, and physics are constantly confronted with questions concerning the nature of man, his immortality, his origin, and his spiritual endowments, the essence of material bodies—their ultimate causes, etc. These questions arise logically from the very nature of the subject matter itself. If the teacher's concept of these all-important matters is vague and indefinite, if his knowledge of psychology and cosmology is meagre and uncertain, at the risk of his own honor and integrity, he is bound to admit his limits and he should recommend the right channels for such knowledge. He would not dare to presume to answer questions in other fields of knowledge, perhaps less remote to his specialty, but in which he had made no definite study. For example, the ordinary teacher of science does not pretend to be an expert in music or art or architecture, but he would hardly say that these cultural disciplines do not exist. A man born blind would not be expected to produce a good treatise on color; but if he is sane and otherwise sound, he will not argue that the sensation of color is a delusion. One should not be like the backwoodsman at the circus who, when he beheld the giraffe, dismissed his surprise and perplexity by saying: "There ain't no such animal."

As teachers of mathematics or science our work is not so much to develop technicians, inventors, and discoverers, as to teach our students to think and to think clearly as well as to know. If we accomplish this, we are not only laying the best foundation for character formation and for real scholarship, but we are making the best contribution toward the development of scientific genius as well. There should be no superficial or slipshod work anywhere, whether in the class room, the laboratory or the field. Every act of man that is worth the doing should be performed in the best possible way; a few problems completely and accurately solved, a limited number of tasks well accom-

plished, have more educational value than a whole course of feverish performances in which there is little or no real cerebral activity.

The majority of those whom we are privileged to direct are not bent upon a scientific career or intent upon becoming teachers of mathematics or science like ourselves. Relatively few of them will make any direct, practical application of the knowledge they will acquire in the class room or laboratory; but indirectly, our teaching, our influence, will color the lives of all of them. This, as teachers, is our great responsibility.

In conclusion, permit me to sum up my message to all teachers and students of science and, particularly, to the young and inexperienced: All of us have had teachers, instructors, research advisers in our scientific studies. It is only natural and just that we appreciate their instruction, their guidance and also their fine peronal qualities and abilities. Only a few of us, however, have been privileged to name among our directors even one professor who was at once a renowned scientist and a well-trained, sound philosopher. This coincidence, if no other reason, gives us basis for comparison and judgment. Most of our scientific advisors were scientists in the most restricted sense, that is, laboratory scientists. They may have made great discovereries; they may have since received high honors for their scientific accomplishments; they may have reached the pinnacle of scientific success. Nevertheless, I say to you: Beware of the false metaphysical premises and the unwarranted generalizations which some of these men themselves or their enthusiastic advocates sometimes infer from their particular data and findings. They may be showered with medals and awards and privileged to wear academic hoods of every color of the rainbow but these do not confer omniscience.

THE SCIENTIST IN THE WAR

Behind our mechanical excellence and our world-famous factory methods there is the solid knowledge of scientists. The scientist has been gaining more and more importance in war. In modern mechanized combat the discoveries he has made in peace-time laboratories are applied to deadly purpose against the enemy. Inventions that have revolutionized anti-aircraft gunnery, radio devices that can spot submarines and planes, medical advances against wounds and disease, and studies of explosives and of protections against explosives are among the youngest children of science. American factories are humming with the production of war equipment which scientists have designed.

MAJOR GENERAL JAMES G. HARBORD

NOTES FROM A MATHEMATICS CLASSROOM

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(*Continued from February issue*)

7. *X* Is Not An Abbreviation. Many texts in algebra introduce literal numbers by referring to the symbols used in shorthand and to the abbreviations used in daily life, such as WGN, C.O.D., and O.K. I have always thought that such an introduction was decidedly wrong, and I am pleased to see that Guy Hawkins of the University of Chicago High School in a review published in *School Review*, June 1941, also condemns that practice.

I favor the use of letters other than x in any problem; the letter that is used should suggest what we are dealing with, such as l for length, w for width, y for years. But l is not an abbreviation for the word length; l is a number. When we consider how long it takes a pupil to learn such a simple fact, we should not introduce any feature that will interfere with the learning.

The same kind of error is made if the pupil is taught to add $6a$ and $4a$ by reminding him that the sum of 6 apples and 4 apples is 10 apples. The sum of $3f$ and $2f$ should have nothing to do with adding three feet and two feet. Such additions are properly taught by asking each pupil to think of a number, to multiply that number by 3 and also by 2, to add the results, and then compare the sum with 5 times his number. He can thus learn that $3f+2f=5f$ is the mathematician's way of saying that the sum of three times any number and twice that number is fives times the number.

To show how slowly the pupils learn that the letters of algebra are numbers I suggest the following test in a class that has had three or four or five semesters of mathematics. At the beginning of some recitation propose the following problem to the class: "The length of this room was measured in yards and also measured in feet. Write the relation between the number of yards and the number of feet, that is, the formula for either y or f." The teacher should not say more than what I have here suggested since any further remarks may spoil the test. The pupils who write $y=3f$ are those who still think that y and f are abbreviations for yard and feet. Those who write $y=\frac{1}{3}f$ have learned that y and f are numbers.

8. Generalizing from Specific Cases. Frequently in the geometry class the teacher needs an example that shows the danger of generalizing from a few examples. One type of example which is appearing with increasing frequency in texts (I do not know who first used it) is:

Find the value of x^2+x+11 for $x=1, 2, 3, 4, \cdots$.

The value of the quantity is a prime number when x is 9 or less. If only these values of x are tried, the class concludes that the quantity represents a prime number.

Using a geometric example, I enjoy saying to the class:

"Suppose you told a man the three sides of a triangle and asked him to compute the perimeter and the area, and suppose the perimeter and the area were the same number. This is true, for example, if the sides are 5, 12 and 13; if the sides are 6, 8, and 10; if the sides are $4\frac{1}{2}$, 20, and $20\frac{1}{2}$. Then suppose you gave him another triangle, and he found that its area and perimeter were the same number; and likewise for another triangle, and another, and another, and another, until he had a billion triangles for all of which the perimeter and the area were the same number. After a billion such examples, don't you think he would say the conclusion is true for all triangles? But he would be wrong. A billion special cases will prove nothing to a mathematician."

Later in the year when the class has studied the theorem about the ratio of the areas of similar triangles, I remind the class of this example. Suppose that p is the perimeter and A the area of a triangle. If the sides of the triangles are multiplied by p/A, the new triangle will be similar to the old one, and the perimeter and area of the new triangle will be equal numerically. Hence it is possible to construct as many such triangles as we wish.

9. Does Ft.×Ft.=Sq. Ft.? Teachers frequently raise the question: Is it correct to say that the area of a rectangle is 5 ft. ×6 ft., or 5×6 sq. ft., or 5×6×1 sq. ft.? The former Professor George W. Myers of the University of Chicago answered the question in my title with an emphatic "yes" in an article published in SCHOOL SCIENCE AND MATHEMATICS, Jan. 1927. Teachers of pedagogy should consider that article carefully.

Engineers and physicists invariably attach the names of the units to the numbers. For example,

What is the cross-section area of a pipe if water flows through it at a rate of 4 mi. an hr., supplying water to 160 acres each week to a depth of 10 in.?

The engineer might write:

$$\frac{160 \text{ acres} \times 43560 \text{ sq. ft.} \times 10/12 \text{ ft.}}{7 \text{ days} \times 24 \text{ hr.} \times 4 \text{ mi. an hr.} \times 5280 \text{ ft.}} = 1.6 \text{ sq. ft.}$$

Attaching the name of the unit to each number enables the computer to see easily what he is doing at each step. The correctness, not of the numerical work but of the operations, is easily understood when examined by another computer. He would very likely check the dimensions of the result by thinking:

days × hours = hours; hours × miles per hour = miles;
miles × feet = feet; acres × 43560 = sq. ft.;
sq. ft. × ft. = cu. ft.; cu. ft. ÷ ft. = sq. ft.

If, in a solid geometry class, a pupil writes $V = abc^2$ for a volume, and if a, b, and c represent lengths, then we can see at once that the formula must be wrong since feet × feet × (feet)^2 cannot be cubic feet.

If one machine can do a job in a minutes and another machine does the same job in b minutes, then together they can do this job in $ab/(a+b)$ minutes. This fraction represents

$$\frac{\text{minutes} \times \text{minutes}}{\text{minutes} + \text{minutes}}.$$

Hence the fraction represents minutes.

And if a pupil should finally ask "Do dollars times dollars make square dollars?" the correct answer is "Yes, in any problem in which it is necessary to multiply dollars by dollars." The economists in Washington could doubtless furnish such problems.

In Bond's *The Professional Treatment of the Subject Matter of Arithmetic* page 252 is the statement "There is good reason for treating all numbers as abstract numbers, and when the computation is fully performed the concrete name may then be attached." The statement is doubtless sufficient for the junior grades for whom Bond was writing, and in the junior grades there are no problems as complicated as those I have mentioned, but high school teachers should have a different attitude.

10. Learning to Use a Theorem. Ten years ago there was frequent controversy over the question whether the first congruence theorems should be proved by superposition or be treated as assumptions. One of the arguments for avoiding superposition was the fact that often a pupil would prove an exercise by re-

peating the superposition proof instead of using the theorem. Hence I raise this question for the class in pedagogy:

Suppose a pupil repeats the superposition proof for an exercise instead of using the previously proved theorem. What should the teacher say to the pupil or class?

Or, if the reader thinks that the question of proof versus assumption is unimportant, let us suppose that the class has proved the theorem about the equality of the base angles of an isosceles triangle. The class then attacks an exercise in which this theorem should be used. The pupil, however, instead of using the theorem, proceeds to bisect the vertex angle and repeats the proof of the theorem itself. What should the teacher say to the class?

I would proceed to question the pupil as follows:

What must you know about a triangle in order to be able to proceed as you did, bisecting the vertex angle, and then getting two congruent triangles?

If two sides are equal, can you always bisect the angle, get two congruent triangles and get the base angles equal?

If you can always do it, why bother to repeat the proof so many times? Why not save time in class by saying merely, "Since two sides are equal we can prove two angles equal by using the proof that we have now heard so many times that we will not bore our audience by repeating it?"

Would this be a sensible attitude to adopt towards any general statement that we prove in the future?

Actually I always *hope that some pupil will repeat* the proof since it gives me the opportunity, as outlined above, to discuss how a general statement should be used. In fact, if I have a bright class and fear that no one will repeat the proof, I interview some pupil before the recitation begins and ask him to do that very thing.

ALLIES' POTENTIAL FIGHTING MEN OUTNUMBER AXIS' MEN TWO-TO-ONE

The United States and its Allies have a two-to-one chance of victory on the basis of manpower, according to an estimate of war-age males in the principal nations at war, by the U. S. Bureau of the Census.

By making fighters of all males between the ages of 18 and 35, the principal belligerents would be able to put 85,203,000 men in the field, not including China, India and the Netherlands Indies. Of this grand total, the Bureau states, 56,643,000 would serve under Allied flags, and 28,560,000 under Axis flags.

STUDIES IN THE TEACHING OF BIOLOGY
I. SUPERIOR SUBSTITUTES FOR CERTAIN CLASSIC LIVING MATERIALS

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For many years, teachers of Biology have been using certain teaching materials in the classroom. Yet the accessible literature does not yield experimental studies which demonstrate that these materials best fit classroom requirements.

This is more strange than is apparent at first glance. In a subject wherein principles and methods of science are stressed, materials are used for reasons which are not based on evidence gathered through investigations employing those principles and methods. Instead, these materials have been accepted on the basis of tradition and convenience. While the same may be generally true of the teaching of other subjects, this does not concern us here.

It seemed very necessary that such an investigation be carried out and is accordingly set forth here. Its purpose is not only to present the facts with regard to specific materials, but to stimulate investigations of a similar nature so that a body of evidence dealing with teaching procedures be made available. Principles are not generally evolved before facts; the Mendelian laws did not come before a body of descriptive material and facts had been made available. Darwin's theory was the pinnacle of a pyramid of verifiable observations and simple experiments; the Laws of Thermodynamics likewise encompass a mass of observation and experiment. Similarly, the procedures which teachers follow in teaching should also be based on verified observation and experiment.

METHODS AND MATERIALS

Two traditional organisms were selected for investigation, namely, the Amoeba and the Paramoecium.

Each material was subjected to the following criteria before it was submitted to experiment.

1. Availability. The material must be conveniently maintained.

2. Size. The material must be suited to observation even by those students who are slow or academically retarded.

3. Source material in the literature. The available literature

should contain sufficient material on the life history and metabolism of the organism.

4. Introduction of Undesirable Principles. The material should not introduce undesirable difficulties in comprehension for the level of study involved.

Once these preliminary criteria were satisfied, the material was used for the experiment. Here different criteria were used to determine the superiority or inferiority of a given material.

1. Ease with which independent accurate observation was carried out.
2. Ease of comprehension.
3. Overt acts of the student.

I. Amoeba

During a three year period, 16 normal high school classes in 10th year Biology with an average of 37 members per class were tested. The average I.Q. of these classes was 102; all of the classes possessed average I.Q.'s near this mark, the lowest average value being 90 and the highest 114. In addition one class whose average I.Q. was 96 and another whose average was 123 were subjected to the experiments. As a result 592 pupils of normal intelligence, 29 of subnormal and 31 of supernormal intelligence were subjected to the tests.

While these data are given, it is felt that they do not bear too forcefully on the results.

Experimental

Chaos chaos, a huge Amoeba whose taxonomic status is not as yet agreed upon, was chosen after some trials as the material to be tested against Amoeba dubia and A. proteus. It is easily cultured (1) by a method, modified from that of Brandwein (2). In fact the writer has found it much easier to maintain than A. proteus or dubia. Chaos is omnivorous and will eat such huge protozoa as Stentor, Frontonia, Blepharisma, Paramoecium and various others. Good specimens, fed on Stentor, are sometimes 25–50 times the size of the ordinary Amoeba. Ordinary specimens of Chaos are about 10–20 times as large as the ordinary Amoeba. If it is fed on Blepharisma, or Stentor, the Chaos shows numerous food vacuoles which are pink and blue-green. The animal may be regarded, in essence as a huge Amoeba possessing the properties of A. proteus and A. dubia in exaggerated form.

Five classes were given Chaos for examination, five were

given A. proteus or A. dubia, and in a final five, alternate rows were given Chaos and the smaller Amoeba. The time necessary to find the animal was recorded in each case.

For the Chaos, one or two animals were placed in a drop of medium and the cover-slip was supported by a bristle or piece of cover glass. The animals could easily be seen macroscopically as white spots on the slide; preparation of the slide was, therefore, simple and efficient. In fact, pseudopodia could be seen by macroscopic examination.

The students were asked to follow a typical exercise on Amoeba similar to that described by Wheat and Fitzpatrick (3) and Kroeber and Wolff (4). The exercises were modified to include questions necessitating more detailed observation and was presented on mimeographed sheets to the students so that reference to illustrations in the text book was avoided.

It is unnecessary to present the exercise here, but it suffices to state that the students were required to find the animal unaided and to observe locomotion, food vacuoles and methods of food getting. When a student found the animal, its discovery was verified by the instructor. The students refrained from communicating; a procedure which was followed in all laboratory exercises.

An average of 5.2 minutes was required by the pupils to find the Chaos under low power. Approximately 50% of the pupils required less than 1.5 minutes, 40% required more than two minutes, while 5% required approximately 4 minutes. The remaining 5% required 5 minutes or more; several pupils required more than 10 minutes.

An average of 17.2 minutes was required to find A. proteus or A. dubia. Approximately 5% found the Amoeba in 1.5 minutes, 15% of the pupils required 5 minutes, 30% required 10 minutes, 30% required 15 minutes, the other twenty required 25 minutes to a period of 45 minutes, while some pupils never found the animal during the period.

In the classes where alternate rows were given the different animals the same ratios in time held. In all cases, an average of 95% of the students found the Chaos in 5 minutes whereas only 20% found the Amoeba in 5 minutes. All students eventually discovered the Chaos within 20 minutes; some students never found the Amoeba while 20% required more than 25 minutes to find this animal.

Other factors which need not be analyzed here enter the picture. The Chaos could be entirely observed and studied under low power of the microscope—food vacuoles, contractile vacuoles, pseudopodia could be easily seen as determined by methods similar to the above. In A. proteus or A. dubia, only pseudopodia could be observed with any degree of certainty. Indeed, food vacuoles were so numerous in the Chaos that in many cases the living prey could still be seen moving within the vacuole.

As it often happens with the beginner in microscopy, the animals are easily lost. They could be rediscovered with ease in the case of Chaos, but with correspondingly greater difficulty in the case of Amoeba. This saving in time must be taken into consideration.

Finally, the complete superiority of the Chaos for subnormal students was made evident when the subnormal class was tested. Fourteen students needed an average of 6.2 minutes to find the Chaos; 15 students required 18.4 minutes to find the Amoeba. The latter mistook many pieces of debris for Amoeba; in a few cases the former made similar mistakes but the mass of streaming protoplasm and the large pseudopodia of the Chaos soon attracted their attention.

There seems to be no doubt when all results are considered that the Chaos is much superior to A. proteus or A. dubia for the high school student. More clearly defined experiments did not seem necessary in view of the rather marked tendency of the data to favor use of the Chaos.

II. Paramoecium

This protozoan has been universally used for study of the protozoan cell. Under favorable circumstances, it is no doubt excellent. But is it the best animal for study under the conditions of the high school classroom? After several trials in which Stentor, Spirostomum and Blepharisma were used as substitutes (7), Blepharisma was chosen as the most satisfactory; the others had certain structural features which made them undesirable.

The structure of Blepharisma has been described (5, 6, 7) and is quite clear; it compares favorably with Paramoecium for study and it is easily maintained (2).

It has many features (7) which make it superior to Paramoecium for study by the high school student.

1. It is colored pink to deep red. This constitutes a label for the student. If cultures of Paramoecium containing Chilamonas

or Colpidium or even rotifers such as Philodina are used, these animals are apt to be mistaken for Paramoecium and attention given to them.

2. It has large oral cilia, or groups of cilia (membranellae) which are in constant motion and which are easily seen under low power.

3. It moves slowly enough to be easily observed. Its movement perhaps is 1/10 to 1/5 as fast as that of the Paramoecium.

4. Blepharisma lateritia, the pink form, is often cannibalistic, so that very large individuals may be found. At any rate, different sizes of individuals are found in a culture illustrating that growth occurs. In Paramoecium, different sizes of individuals are very difficult to find.

5. It has one large contractile vacuole in its posterior region; this appears colorless in a pink body and accordingly is very conspicuous. Similarly, food vacuoles are also conspicuous.

6. There are macro and micronuclei in beaded form which condense before division. Each new culture contains numerous individuals in fission, and it is not uncommon to find 10% or more of the prepared slides of living individuals showing division.

Experimental

Each student was given a mimeographed sheet containing a description of the methods of locomotion, types of food vacuoles, contractile vacuoles and methods of asexual reproduction of ciliates—e.g. Paramoecium and Blepharisma. The organisms, however, were not named but were labelled A, B, and the student was cautioned to consider them as types. In this way, the student was forced to observe independently. He was not permitted to refer to a textbook. The exercise, further, did not direct his attention to the appearance of the structure in the animal. Unfortunately, most laboratory exercises do so in such a manner that the student does not have the opportunity to think reflectively.

For instance, in a description of the contractile vacuole, the student was offered the following, in part. "Many protozoa which live in fresh water possess clear, spherical structures which eliminate the excess water which enters by diffusion. These structures are called contractile vacuoles. As you may guess from the name, water enters these structures and when they are full, they contract. By their contraction, the water is eliminated. This process (taking up water and contracting when

full) is repeated in rhythm. Type A has one vacuole (drawing given here with an x marking the probable location). Type B has two vacuoles, which contract alternately (drawing as before but with two x's). In some similar way, most of the organelles of importance to the high school student were described. In the exercise, the students were asked to find and describe these organelles by suitable drawings and labelling.

In three classes, a wet mount containing relatively equal amounts of Paramoecium and Blepharisma was given to each student. A No. 2 cover slip was used. No methods were used to trap the animals.

Within five minutes, a vote was taken to see which animal was being studied. 84% of the students reported that they were studying the pink animal Blepharisma, 16% reported studying the Paramoecium. The reason most often given was "that the pink animal moved so slowly."

Within 10 minutes, the No. 2 cover slip had begun to press down on the animals to slow their movements considerably so that the Paramoecium could also be studied.

In two classes, the animals were mounted on slides on which lens paper had been teased out entrapping the animals. After five minutes, it was found that 90% of the class was studying Blepharisma. Here several reasons were given:—

1) It was the first one that was found.
2) "Things" were clearer in it.
3) The color was attractive.

The students were given a choice of drawing either animal and labelling the structures. In the first case, where the wet mount without lens paper was used, 91% drew Blepharisma; in the second case, 84% drew Blepharisma. From the standpoint of accuracy the drawings of Blepharisma were much superior to those of Paramoecium, an average rating of B was given to drawings of the former as compared with an average rating of C for the latter.

The reason is not difficult to find. The structures in the Blepharisma are almost diagrammatic; cilia, contractile vacuole, food vacuoles and oral groove stand out clearly.

The following table summarizes the results as established from student answers and drawings on the mimeographed sheet. The mimeographed sheet asked for the animal in which the structure was observed.

Structure	Blepharisma % of Students	Paramoecium % of Students
Cilia	93%	7%
Contractile Vacuole	97	22
Food Vacuole	72	34
Oral Groove	96	72
Division	11	0
Animals of Different sizes	67	0
Mistaken for other animals	0	12*

* (Colpidium or Philodina.)

In each case, the answer was checked with the drawing. In some cases, students were able to observe the structure in both animals. In 3% of the individuals who drew Blepharisma, the oral groove was not represented accurately; 30% of the individuals made a similar error for Paramoecium. In only two cases were the contractile vacuoles of the Paramoecium represented correctly. In most cases only one was shown and in the majority of cases the canals were omitted.

A very important consideration was that the observations on Blepharisma could be carried out under low power. Those on the Paramoecium for the most part had to be carried out under high power.

It seems clear that the Blepharisma is superior to the Paramoecium for study by high school students.

Preliminary study also indicates that the Spirogyra has very little to recommend it and that there are other cells to replace it in the high school laboratory.

Discussion

This is the first of a series of investigations on materials and methods in the teaching of biological science. A discussion of the bearing of these results on teaching may best be left to a later paper. Let it suffice for the present to state that the inertia induced by the textbook is a powerful one; it is indeed, very difficult to overcome. Similar is the inertia induced by educational practice which too often is based on theory and not on fact garnered through scientific investigation. Is it pertinent to ask why educators who teach that scientific method is responsible for our most valid practices, do not attempt to investigate every bit of teaching practice by these methods?

There is no doubt that many teachers are already using Chaos chaos since the animal has been advertised for sale by supply houses but it is proper and necessary to ask for the facts upon

which they base their use. Casual observation and pure logic is not enough in science; the latter abounds with examples of logic negated by experiment. Neither is it valid to dismiss scientific method as it applies to methods in education becausee too often it proves what logic has already indicated. On the contrary, when logic indicates a desirable procedure the method of science should validate it, if possible. More important, this practice will in the years to come build up a pyramid of facts from which principles may be gleaned. It will possibly be true (as it has been true of most scientific investigations) that these facts will appear to be unrelated. But if enough are gathered they will eventually be related by the investigator who happens to examine enough of them.

To recapitulate, just as the principles of our sciences were based on myriads of facts discovered scientifically, and just as the statement of principles had to await the gathering of these facts, so must principles of science teaching await a mass of facts. To date, these facts are lacking. Words will not replace them.

Summary

1. Chaos chaos has been found superior to Amoeba proteus for classroom study in the George Washington and Forest Hills High Schools, New York City.

2. Similarly, Blepharisma lateritia has been found superior to Paramoecium caudatum.

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It is true of all natural science, and especially of physics, that it can never fall into such lasting mistakes as we find in other fields of intellectual life, since physics is concerned with the unchanging laws of nature, which have their being independently of human activity.—C. Møller and Ebbe Rasmussen.

The World and the Atom.

HOW CAN THE SCIENCE CURRICULUM SCHOOL HELP TEACHERS?*

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The curriculum center school fills the same need in a school system that the experimental laboratory supplies in the industrial world. Experimentation is costly, but without it there would be little progress. Developing or revising a course of study, trying out equipment, visual materials, and various types of supplies, and examining available books, are all essential to the forward-looking school system, but it would be foolishly extravagant for every teacher, or every school, to do this experimental work. Very few school systems could afford it.

In February, 1928, Cleveland attempted to meet the need for experimentation in many phases of the elementary school field by instituting curriculum center schools, one for each subject in the curriculum. It was at that time that elementary science was added to the subjects to be taught, and to Doan School was assigned the problem of developing a curriculum in science for grades one to six. Until June of 1941—thirteen and one-half years—the experimental work continued at Doan School. This fall the center has been transferred to Miles Standish School and experimentation is once more taken up with a different group of children.

During this thirteen-year period what has been accomplished? Is a curriculum center school really worth while? Probably the best way to determine this is to examine some of the ways in which we are attempting to serve the teachers and pupils of the Cleveland public schools.

At the curriculum center we believe that our pre-eminent function is to experiment with the many ways in which boys and girls learn science. From this search for effective learning situations we hope to accomplish several goals:

1. To determine what scientific experiences are needed by boys and girls in order for them to live happy and successful lives. This includes learning how to solve their problems scientifically.

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* Read before the Elementary Science Section of the Central Association of Science and Mathematics Teachers, Nov. 22, 1941.

2. To discover a wide range of interests for leisure time occupations.

3. To utilize all types of learning activities in order to provide for differences in ability, interest, and available materials.

4. To share the results of our experimentation with others who are teaching science.

Whatever other contributions we may have made are by-products of these four purposes. Science radio lessons, studies of books, development of visual materials, preparation of exhibits, experiments with supplies and equipment,—all have grown out of our exploration of ways in which children learn science.

The most important contribution of the curriculum center school is that of showing the value of elementary science. Now that we realize what science can do for the boys and girls in our classes we cannot understand why we neglected for so many years the dynamic materials which were directly at hand.

Elementary science goes a long way toward solving the child's problems which arise in and through contact with his environment; it teaches him how to find answers to his own questions; it gives him real,—not vicarious,—experiences on his own level of ability; it opens a wide range of interests for his leisure time; it vitalizes his entire day, in school and out.

When the science center was in its infancy the teachers were told to concentrate their efforts upon developing some units in natural and physical science and not to be too much concerned about the other subjects until the science was under way. Of course, the teachers were worried about the three R's, so, at the end of the year, a standardized achievement test was administered. The results amazed the teachers: in all subjects except arithmetic the pupils were considerably above the norm for their grade. Each year the grade medians were higher, showing that the growth was continuous. They had been doing more reading, more oral and written English, more spelling, more research into related fields of geography and history than ever before.

This fall in the new curriculum center where science has not previously been greatly emphasized we are again watching this vitalizing effect. A general interest in school and in all school subjects is evident. Last week a mother of a sixth grade girl said, "Joan was not much interested in school last year, but this year she likes it so well that we hear about what she is doing at school at breakfast, lunch, and dinner. She is very happy."

In fact, an air of busy happiness is beginning to pervade the entire building, and, as the pupils are becoming intent upon their various projects, discipline problems are decreasing. The reference books and encyclopedias are being consulted frequently, letters are being written to invite others to participate in a tree-planting ceremony, a tree map of the district is being made to show where we need to plant more trees, a class is going to the Museum of Natural History for a lesson which will help them to understand the development of life on the earth. Another class, equipped with water colors and a pail of water are on their way to the adjacent park to make paintings of trees in their autumn foliage. In short, school work is no longer humdrum for them, and because they are finding their days filled with busy worthwhile activities, they are happy. Every teacher knows that learning proceeds best in a happy atmosphere. If the curriculum center school performs no other service than to demonstrate what science can do for boys and girls, it has justified its existence.

The old, old maxim, "We learn to do by doing," is never so true as in the field of science, but we might strike out two of the words and arrive at still another truth: "We learn by doing." Boys and girls do not completely learn when someone else does the manipulation. Neither do they completely learn when they merely read about or discuss the problem. It is only when they do something about it that they realize its true significance.

Henry Turner Bailey, for many years the Dean of the Cleveland School of Art, once said, "What we learn is directly proportional to the square of the number of senses through which the knowledge comes." "Doing," therefore, should consist of many kinds of activities. Reading and discussing, it is true, are valuable activities but so are modelling, building, drawing, experimenting, taking a field trip, giving a talk, preparing a dramatization, setting up an exhibit, making a chart, planting and caring for growing things, and performing such menial tasks as cleaning out the animal cages, or dusting the science shelf. In an effective learning situation, such activities are never isolated projects, but are always part of the process of solving the problems under consideration. And because these experiences are real to the children, the concomitant learnings in the complete situation reach far beyond the boundaries of science.

To illustrate the possibilities of varied types of activities in the science workshop, let us observe a few learning situations

chosen at random from the daily happenings at the curriculum center school.

Here is a first year class. Out of doors a high wind has been blowing for several hours, a wind so strong that it has bent even the large trees outside their classroom window. When we step into the room some of the children have gone outside to see how the wind feels. As they struggle to retain their balance, those inside notice their flying hair and skirts and scarfs. "That wind pushed me!" exclaims one child when she returns to the room. Then at the suggestion of the teacher, all of them go outside to feel the wind for a minute or two. When they come back they want to "play" the wind, so they create a new rhythm to represent the swaying trees. Then several of them paint or draw pictures to show what the wind did to the trees and to themselves. These boys and girls will never forget the power of the wind: the *impression* of the experience followed by different types of *expression* have constituted for them a dynamic learning situation.

Let us examine another learning situation.

When we looked out of the window a few days ago we saw a group of third-year children with their teacher, carefully measuring off a plot among the shrubs where they might plant a few daffodil bulbs to improve the appearance of the front yard in the spring. They measured and drove in stakes and then dug a trench six inches deep for their bulbs. Previous to the actual work they had found out the rules for planting daffodil bulbs out of doors, they had opened one bulb to find the baby plant and to see the layers of food surrounding it, they had planted many bulbs in bowls to take home and to brighten their school room later on, and they had learned why some flowers bloom so much earlier in the spring than others.

Next let us step into another primary classroom.

Here the boys and girls are putting the finishing touches to a miniature farm which they have been constructing in the corner of their room. Because it was too far for the class to go visit a real farm, they have drawn upon one another's individual experiences, have looked at moving pictures, and have read many books to get the necessary background of information. Valuable mathematical experiences have entered into their decisions concerning sizes of buildings and fields, and countless measuring problems have arisen in laying out the plan on the floor. At different times during their study of farm animals they have had

a duck, a turkey, and some chickens in the animal cage in the room. It would take too long to enumerate all the activities in which they have engaged, but each has contributed to an understanding and appreciation of rural life. Science problems encountered have included such important questions as "How do we use the plants that grow on the farm?" "What do we get from the animals on the farm?" "How does the farmer help us?" "What machines does the farmer use to help him do his work?" "How does milk get from the farm to us?" "How does the farmer take care of the baby animals?"

Now let us visit an upper-grade science room. The boys and girls are just assembling for the morning session.

A committee of fourth-grade children have come in to look after their part of the science shelf. They are checking to see that their groupings of Living Things are correct. One member of the committee is adding a drawing to the pictorial record of the growth of some tadpoles.

At the other end of the shelf a few fifth-grade children are clearing a space to display some examples of chemical changes: a bottle of sour milk, a rusty nail, some sugar and the carbon which had resulted from burning sugar in a test tube on the previous day.

The bell rings and these children go back to their home rooms while a sixth-grade science class assembles. What is their problem to-day? In the course of their investigation of the everyday uses of electricity they have asked what made the electrical bell ring, so the teacher has brought out enough electric bells, push buttons, dry cells, tools and wire for each of the seven tables in the room. Referring the boys to diagrams and explanations in the science books at hand, she suggests that they try to discover how to make a bell ring. At once the room is alive with intense interest. When successful achievement comes to one group after almost thirty minutes of study and experimentation, they shout, "We have it!" But the other groups ask them not to give away the secret as they want to solve the problem for themselves.

When we consult the teacher later she tells us that all groups have at last succeeded in making the bell ring, but that some of them have spent their recess time, part of their noon hour, and some after school time on the problem.

Had you watched those boys and girls at work you would have agreed that it would have been false economy for the teacher to

have demonstrated to the class the wiring of the electric bell.

It is small wonder that our boys and girls say, "Gee! schoo is fun!"

And how do the teachers of the city benefit from the activities that we work out at the curriculum center?

Of course, teachers may visit the school, individually or in small groups, at any time, and occasionally we arrange a demonstration for larger groups, but many of these pupil activities find their way into our course of study as suggestive procedures and into the science radio lessons which are broadcast weekly.

Two or three times at Doan School the entire school cooperated in holding a ten-day Science Fair to which all the science teachers in the city were invited. Boys and girls in hour relays demonstrated their experiments and explained their charts and exhibits to all who came. In this way, a double purpose was accomplished: a review of the year's work for the pupils, and a suggestive source of pupil activities for other science teachers.

The radio lessons in science are helping more than any other one agent to extend the work of the curriculum center and to aid the supervisor in launching the science program in all the schools of the city. These weekly broadcasts of about twenty minutes each direct learning situations in the classroom. No school is required to take these radio lessons but they are proving so challenging that one or more classes in every school are taking them. Contrary to the belief of those unacquainted with the lessons, these broadcasts do not standardize procedures. What happens after the broadcast, varies widely with every group of pupils receiving the lessons.

The broadcasts are a cooperative product under the direction of Miss Mary Melrose, the supervisor of elementary science. The first draft of the script is written by a teacher, who is usually, but not always, directly connected with the curriculum center. This first trial script is broadcast to four or five schools of different types. The principals of these schools meet with the writer of the lesson and the supervisor to discuss revisions. Then follows rewriting and a second trial. Therefore, when the lesson goes over the air in final form it is the result of the best efforts of several persons. In all this, the curriculum center school plays a very definite part. Besides furnishing some of the writers and broadcasters of the lessons, the curriculum center school helps to prepare bibliographies and visual materials to accompany the teachers' direction sheets. Then, too, most of the activities have

previously been tried out in curriculum center classrooms.

Answers to questionnaires sent to all teachers receiving radio lessons in science show that these lessons are helping teachers in these ways:

1. By suggesting activities of many kinds.
2. By furnishing visual materials.
3. By indicating the basic understandings to be developed.
4. By enabling them to observe, and at the same time to participate in, many dynamic learning situations.
5. By giving them an annotated bibliography for each unit.
6. By indicating efficient ways of organizing children, materials and subject matter.
7. By showing effective ways of using books.

In cooperation with the Educational Museum, we have attempted to develop visual aids to accompany each science unit. In the teaching of elementary science, the cardinal principle is to see that real materials are used whenever possible. But these materials can and should be supplemented with carefully prepared visual aids of other kinds. When the curriculum center was established the Educational Museum could furnish the schools with sets of mounted pictures and with some exhibits but there was a definite need for lantern slides and later, for moving pictures adapted to the young child.

Working together, we have developed a set of lantern slides for each grade. These are of several kinds:

1. The photographic slide in black and white. These may be used for the purpose of clarifying a concept or presenting a picture of something which cannot be brought to the classroom. Or, they may be pictures of boys and girls engaged in science activities.

   Ex. Snowy Egrets in bird sanctuary.

   Ex. Making a home for Peter's turtle.
2. The photographic slide in color. Here we have been slow in our experimenting because colored slides are expensive. We hope to experiment with Kodachrome at an early date. Many of our nature slides fail to develop correct visual concepts because they are not in natural color.
3. The transolene slide, used to show diagrammatic representations, to present problems to be solved, and to stimulate or direct experiments.

On two of these slides, we have summarized for the fifth and

sixth grade child, some things to think about when he attempts to find the answer to a question by experimenting. The slides are these:

Slide #1 Performing an Experiment
1. State the problem.
2. Get the materials you will need.
3. Follow the directions exactly.
4. Tell what happens.
5. Tell what this seems to prove.
6. Answer the problem.

Slide #2 Testing the Truth of Your Answer
1. Have some other person do the experiment.
2. Consult science books.
3. Try other experiments that might help to answer the questions.

Gradually, the number of good films for the silent machine and for the sound machine is increasing. The curriculum center school attempts to try out as many of these films as possible and to recommend ways of using them. Then, weekly bulletins from the Educational Museum notify all schools of new films available for ordering.

It is also part of our service to teachers of elementary science to acquaint them with the worth-while books for pupil and teacher use. This need was so acute when the curriculum center was first established that an annotated *Science Reader's Guide* was assembled, listing references on different topics in natural and physical science. Two editions of the *Reader's Guide* are within reach of every science teacher in the city. In addition, each unit in radio science is accompanied by a bibliography of the best books available on the subject. Then, annually, the science supplementary book list is revised, to enable schools to purchase only the best books in each field.

The Cleveland Public Library cooperates to its utmost in the effort to make available science reference material of high quality. Since the market is flooded with quantities of third-rate science books for children, teachers as well as librarians must be alert to the qualities desirable in a science book to be recommended for use by boys and girls. A good science book presents fact: books of fancy belong in another category. It is expressed in good, straightforward English; its vocabulary and sentence structure are geared to the reading level of the age for which it is intended.

Why does an author writing for children, spoil an otherwise valuable publication by "fancy" writing like this?

"We have already learned that like poles of magnets such as

two souths are hostile to each other and exert repulsion rather than the attraction that is normally associated with magnetism. Hence, if the south pole of the magnet is pointed toward the compass needle, the north pole of the needle will be attracted. A mere vice versa supplies the rest of the answer."

Another author who knows more about children and just as much about magnets, writes: "You have found that when two north poles of magnets are brought near each other they push each other away. Two poles of the same kind are called like poles. If a scientist were telling this, he would say, 'Like poles of magnets repel each other. Repel means to push away.'"

The illustrations in a good science book are simple, photographic, clear, and when in color, colored accurately. Since pictures are such potent learning materials, we must be sure that no misconceptions can arise from studying them. Are they merely pretty pictures, or are they both artistic *and* true? Are they an integral part of the learning situation or information described on the page or do they merely occupy space? The captions are important, too: they should provoke thought, stimulate the pupil to ask questions, or present problems for him to solve.

A table of contents and an index are indispensable, and, if the subject is a specialized one, a glossary is desirable. We should look, too, for a durable binding, generous margins, and print that conforms with the requirements for the pupil's reading age.

The curriculum center school experiments with equipment and supplies for the science room. As very few schools can afford enough supplies for every pupil, it is almost a necessity to concentrate upon one room for a science work shop, to which classes may go for science as they go to a specially equipped handcraft shop for industrial art.

In our new center where the regular classrooms are too small for science activities, partitions have been removed between three adjacent classrooms and a new partition constructed across the middle of the middle room. This has given us two science rooms which are adequate to serve classes of forty to forty-five pupils.

A linoleum-covered science shelf has been built at window height along one side of the room and a sink installed in an inconspicuous place. The furniture consists of linoleum-topped tables, sturdy chairs, a work table, a reading table, an exhibit case and a combination teacher's desk and demonstration table

with electrical connections. There is storage space for science supplies in an adjoining remodeled cloakroom.

In other rooms we are experimenting to find ways of handling pupil groups, supplies, etc., in rooms with stationary desks, and in rooms equipped with movable desks. We are convinced that of all types of furniture for the science room, the tables and chairs lend themselves most effectively to small group experimentation and to the most economical use of supplies. To buy enough equipment to supply each of forty pupils with what would be needed for the experiments in electricity, would be far too costly, but a school might be able to purchase enough for six or seven groups working around tables. In addition, the challenge of the group situation is a potent stimulation to thinking.

We are equally sure that the one most valuable piece of equipment in an elementary science room is the science shelf. On the shelf, pupils may display exhibits, collections, and living things, grouping and re-grouping them to keep pace with their developing knowledge, and changing them whenever new occasions necessitate. All classes can share the responsibility for the shelf, and exhibits can frequently be used to review problems for a class that has previously studied the unit.

Over a period of years we have developed an order list for supplies for elementary science. Each year we carefully scrutinize this list for revision. We study the needs of the pupils, the requirements of the topics studied, and then search for inexpensive supplies to fill these needs.

Development of a civic consciousness on the part of the pupils and establishing relations of the schools with the public are becoming increasingly important. The science curriculum center finds many opportunities to show teachers how to cooperate with different community agencies whose interests touch the science program. Last year groups of children who had been making a study of conservation talked at the Garden Center, at the education section of the Federated Women's Clubs, at the Sportsmen's show, at a meeting of the Cuyahoga County Conservation Council, and at the science section of the Northeastern Ohio Teachers' Association. All these citizen groups were impressed by the serious presentation of the subject of conservation by the boys and girls.

Cleveland's extensive park system and its Cultural Gardens honoring all nations are famous. To combat thoughtless van-

dalism in these parks and gardens, the Cleveland Garden Center suggested that we organize a Park Protection Club. This idea has extended to many other schools. The activities of this club have brought about valuable contacts with the City Parks Department, the Metropolitan Park Board, and Conservation Clubs.

On one occasion, they presented the city with three signs, showing the quoted precept: "Let no one say, and to your shame, that all was beauty here until you came." These signs were placed in the Cultural Gardens. Up to the present time, they have never been defaced.

This fall, following a suggestion in Margaret Suhr Reed's column in the *Cleveland Plain Dealer,* the boys and girls of Miles Standish School planted buckeye seeds in flats and in the park near the school. The City Department of Parks was more than willing to grant permission for the outdoor planting. The boys and girls invited representatives from nearby schools to share in the project and a few interested adults from conservation organizations to assist in their planting ceremony on Armistice Day.

The force of the enthusiasm for conservation which was generated by this occasion is, of course, incalculable, but every person present at the assembly felt the eager interest of the pupil audience to carry on the project begun that day.

Such contacts as these not only constitute a favorable type of advertising for the work of the public schools, but also train the boys and girls for the responsibility of citizenship in city life.

As a result of all these different types of experimentation in the field of elementary science, a course of study is gradually evolving. From the beginning, it has been a cooperative project participated in by pupils, teachers and supervisor. Briefly, our method of working is as follows: At the curriculum center a unit is initiated by the pupils or the teacher, or suggested by the principal or supervisor. During a period of leisurely experimentation the various ramifications of the problem are investigated by teachers and class; activities of all sorts are engaged in; pertinent books, pictures, slides, movies, and field trips are tried out; and possible correlations with other phases of the curriculum are explored.

The teacher then puts the unit in tentative written form, indicating the problems which arose, and the pupil activities which led to the basic understandings necessary to answer the

main questions of the unit. She also makes a suggestive list of actual materials, visual aids and reading references which both the pupils and the teacher have found useful.

Then ensues a year or two of further experimentation by teachers in different kinds of schools throughout the city. These teachers suggest revisions of the original unit. Perhaps the next year this same unit will be taught via the radio and all teachers will be invited to send in suggestions. At last the unit is placed in the course of study—not, however, to remain there unquestioned, for the Cleveland course of study in elementary science is in a state of perpetual reexamination and revision.

Because of the many hours of thought which they spend in helping to evolve a course of study, interested and alert teachers derive much benefit from the work. Their course of study is not merely a book or pamphlet resting in the desk drawer, but a vital part of their own experience. They understand its significance and know what it contains because they have helped to build it. The elementary science work in every school in Cleveland, we believe, is the justification for the time, effort, and money spent in curriculum school experimentation.

THE TEXTBOOK OUTLOOK

Rumors of impending shortages in all sorts of materials are flying about these days. Some are undeniably true; some have little or no foundation.

Numerous enquiries have been made concerning the possibility of a shortage of book paper. Instances have been reported of some school executives who, hearing that new textbooks might be hard to procure in 1942, have had expensive repairs made on old books at a cost approaching the price of new editions of the same books.

Schoolmen will be glad to learn that the outlook at the present moment appears to include no threat of a paper shortage which will prevent the manufacture of all new textbooks required to meet the needs of this country for the next year.

Leon Henderson, Federal Price Administrator, in an address delivered at Hot Springs, Virginia, on November 13, 1941 before the Association of Advertisers and the American Association of Advertising Agencies said:

"According to present data the supplies of newsprint and book paper appear adequate for the next year in spite of the fact that defense activities are consuming about 20% of the nation's output. . . . Unfortunately, uninformed reports of a great paper shortage have tended to create a tight delivery situation on many kinds of paper and it is our information there exists rather extensive hoarding by some users. This condition has tended to magnify whatever shortage may exist and were it not for this fear it is our belief that supplies of paper at this time would be fairly adequate for practically all users."

A SELF-RATING CHECK SHEET FOR PROGRESSIVE PRACTICE IN ELEMENTARY MATHEMATICS AND SCIENCE

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Teachers of mathematics and science should not be criticized for frequently turning a deaf ear to the exhortations of general curriculum revisers who desire comprehensive changes in teaching. A continuous, withering blast of newer educational theory and terminology has engulfed and somewhat insensitized these teachers to the unending, unnumerable stream of proposals. They have a daily classroom job to do that involves heavy teaching loads and complex responsibilities. There is little time available in the standard school for trying out uncertain, untested, or unproven practices.

Many teachers feel that laboratory schools and demonstration centers may have both time and freedom for investigating new hypotheses and techniques. But there is too little liberty for experimentation in standard schools existing day by day under the surveillance and pressure of administrators, supervisors, principals, school trustees, laymen, P.T.A. members, course-of-study makers, and the standards of one's associates. However, as changes are taking place in science and mathematics instruction, teachers are interested to know where they stand in the scale of modern practice. Harold Spears[1] offers the following six forms of curriculum organization which may be interpreted in relation to the fields of science and mathematics for the purpose of appraising modern practice.

1. Subject matter organization
2. Correlation of subject matter
3. Fusion of subject matter
4. Broad fields involving science and mathematics
5. Core curriculum involving science and mathematics
6. Experience curriculum involving science and mathematics

The following is a digest of the six topics.

1. *In subject matter organization.* Science and mathematics are taught as entirely separate subjects or units. Definite periods

[1] Spears, Harold. *The Emerging High School Curriculum.* American Book Co., Cincinnati. 1940.

are scheduled throughout the week for these subjects. Only incidental relationship between the fields is demonstrated by the teacher. There is also no relationship shown with other organized school work in social studies, literature, recreation, healthful activities, arts, etc. However, even under this organizaiton, a teacher may relate the class work to the vital interests and needs of pupils. In mathematics and science, the problems studied may be drawn from the experiences of children. While much fine teaching is being done under this form of organization, yet it may be classified as the basic, unarticulated method of instruction.

2. *In the correlated curriculum.* Teachers plan to provide definite relationships between such fields as mathematics, science, and social studies. Several teachers may cooperate so that coordination of experience takes place among the subjects. There would be planning for the consideration of science aspects relevant to arithmetic and vice versa. This principle of concomitant teaching of experiences common to several areas would include other subjects as health, and industrial arts. The cooperating teachers might devise a number of major correlating problems so that exceptional articulative teaching can be carried on.

3. *The concept of the fused curriculum* eliminates the artificial aspects of planned correlation since the educational experiences of the unified areas will be taught without regard for subject boundaries. The technical problems involved in simultaneous teaching of several subjects are far less difficult than ordinarily conceived and the barriers frequently consist of "psychological blocks" or resistance to the disturbance of "established patterns of behavior" in the teacher's mind. There would probably be more acceptance of new organized plans if teachers realized that there is no intention on the part of curriculum makers to eliminate the mastery of certain processes. Time is provided for the development of proficiency in mathematical combinations, for the comprehension of basic concepts, and for the establishment of worthwhile attitudes and ideals. The process of fusion provides a broader basis for an approach to life problems involving mathematics and science. Numerous problems may be developed that involve the principles and practices of both mathematics and science. These problems may originate in the normal interests and activities of children.

4. *The broad fields* form of organization is a compromise between the subject matter approach of correlation and fusion,

and the more liberal activity procedure. It can be administered quite conservatively or progressively. Broad fields such as "Man's Social Relationships" or "Man's Relationship with the Universe" may open the whole field of science to children. Teachers with some ingenuity can also develop many mathematical situations of significance to children. This would be done without overlooking the mastery of the techniques essential to success in mathematics and science.

5. *The core curriculum* is characterized by teacher planning of a common program of integrative experiences. In the elementary schools, the sequence of experiences would involve contact with every standard area of the curriculum without consideration of subject matter boundaries. However, for the acquirement of certain skills needed in mathematics and science, practice periods would be provided. A continuous, planned core would be carried through the elementary schools into the Junior and Senior High Schools. Where specialization of a specific nature is needed at any level, provision is made for such work. Mathematics and science in all their aspects would play an important role throughout the program. The core is designed to give students vital experiences which are generative of considerable individual and social effectiveness. Except in specialized electives, all subject matter boundaries would be eliminated and all fields would contribute their essential qualities to aid the pupil in solving present, and probably his future, life problems.

6. *The experience curriculum* is distinguished by its procedure in eliminating teacher preplanning from the program. The activity of the school is oriented to the dynamic needs of students in their natural environments; the home, the community and the school. Although the teacher makes no outline of pupil experience, she comes to the school exceedingly well equipped in experience, education and attitudes for aiding pupils in meeting life situations. The teacher guides the unfolding of the curriculum as she develops insight into the needs of the children for natural growth and for control of their total environment. In this concept of curriculum, mathematics and science would play leads in the solution of problems significant to children. The teachers would keep in mind that adequate individuals are masters of the tools needed for efficient living in the world. Where the fields of mathematics and science can contribute such fundamental instruments, the educational leaders would provide time for their mastery. The motivation for learning comes from

the conditions of the home, school and community. This type of curriculum is to be found in numerous small communities of the south where epoch-making pioneering efforts are being made.

From a study of these six curricular organizations, it should be apparent that a teacher well trained in mathematics and/or science would find tremendous educational challenge in any one. Through a broader understanding of the function of the modern school, teachers and administrators are finding it expedient to liberalize their viewpoints. Whether we approve of this or not, the general trend in the teaching of mathematics and science, as well as in other fields, is toward the more functional approaches. Ten years from now there will be other organization forms than these six to characterize and define curricular practice. Such change is, of course, hopeful for improvement in the effectiveness of the American educational program.

The following inventory of educational practice is designed to aid teachers in the appraisement of moderness in educational organization and application. Such a basis of evaluation must include the aspects of curricular emphasis to be found in the traditional as well as the modern school. The items of this inventory were primarily drawn from suggestions in *The Child and His Curriculum.*[2]

1. To what degree are the relationships emphasized between the offerings of mathematics-science courses and the problem of pupils in their homes, the school and the community?
   ____none; ____slight; ____some; ____considerable; ____very much.
2. To what degree is the mathematics-science work meaningful to students in consideration of their backgrounds and experiences?
   ____none; ____slight; ____some; ____considerable; ____very much.
3. To what degree are the students guided into projects involving community participation as a result of mathematics-science experience?
   ____none; ____slight; ____some; ____considerable; ____very much.
4. To what degree are student interests used in planning mathematics-science experiences in the school?
   ____none; ____slight; ____some; ____considerable; ____very much.
5. To what degree are student goals and life purposes utilized in planning school work in mathematics and science?
   ____none; ____slight; ____some; ____considerable; ____very much.
6. To what degree is student participation employed by the teacher in actually planning school experience in mathematics and science?
   ____none; ____slight; ____some; ____considerable; ____very much.
7. To what extent are the immediate needs of students utilized in planning school experience in mathematics and science?
   ____none; ____slight; ____some; ____considerable; ____very much.
8. To what degree is the mathematics-science material offered in school

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[2] Lee, J. M. and Lee, D. M. *The Child and His Curriculum.* D. Appleton-Century Company, Inc., New York, 1940. Chapter V.

actually suitable to the backgrounds and maturation of the pupils?
____none; ____slight; ____some; ____considerable; ____very much

9. To what extent is the science-mathematics material offered to pupils within their rate of comprehension or pace of learning?
____none; ____slight; ____some; ____considerable; ____very much.

10. To what extent does the mathematics-science teacher deviate from being a classroom director and examiner to be a sympathetic competent guide to pupils?
____none; ____slight; ____some; ____considerable; ____very much.

11. To what extent has the mathematics-science teacher displaced classroom competition and conflict with wholesome friendly, cooperation?
____none; ____slight; ____some; ____considerable; ____very much.

12. To what extent has mastery of fundamentals in science-mathematics by sustained drilling been replaced by discriminating and "purposeful repetition?"
____none; ____slight; ____some; ____considerable; ____very much.

13. To what extent has the process of mastering fundamentals been implemented by learning through experience in meaningful situations?
____none; ____slight; ____some; ____considerable; ____very much.

14. To what extent is learning in mathematics-science classes facilitated by utilization of the modified-whole method?
____none; ____slight; ____some; ____considerable; ____very much.

15. To what degree has the "study-recitation" method been implemented with activities in projects, problems and educational aids?
____none; ____slight; ____some; ____considerable; ____very much.

16. To what extent is learning being encouraged by praise rather than by punishment?
____none; ____slight; ____some; ____considerable; ____very much.

17. To what extent does the mathematics-science teacher facilitate learning by keeping pupils informed of their progress?
____none; ____slight; ____some; ____considerable; ____very much.

18. To what extent does the mathematics-science teacher facilitate learning by keeping pupils informed of their progress?
____none; ____slight; ____some; ____considerable; ____very much.

19. To what extent does the mathematics-science teacher correct errors promptly and make provision for developing correct responses?
____none; ____slight; ____some; ____considerable; ____very much.

20. To what extent does the mathematics-science teacher stimulate pupils to do work of a creative nature in her classes.
____none; ____slight; ____some; ____considerable; ____very much.

SYNTHETIC EPHEDRINE SUPPLIES SEEN AMPLE BY OPM

There will be no shortage of the cold-relieving drug ephedrine, despite stoppage of supplies from China.

Synthetic ephedrine, developed by American chemists, is made in quantity sufficient to supply all U. S. needs, an OPM spokesman said.

The drug is an astringent, used to open stopped-up nasal passages in colds, hay-fever and asthma. It is also a circulatory stimulant like its cousin epinephrine.

Natural ephedrine is made from the Ma-Haung plant which grows in China. It was successfully synthesized by American science in 1926. Much of the ephedrine now on the market is synthetic.

EASTERN ASSOCIATION OF PHYSICS TEACHERS

One Hundred Forty-Ninth Meeting

BOSTON COLLEGE

Commonwealth Avenue, Newton, Mass.

Saturday, December 6, 1941

MORNING PROGRAM

A Joint Session *with*
The New England Biological Association
and
The New England Association of Chemistry Teachers

9:45 Address of Welcome: The Rev. William Murphy, S.J., President of Boston College.
10:00 Address: Wartime Gases: Mr. Louis Welch, Boston School Dept.
10:45 Address: Cosmic Rays: The Rev. John A. Tobin S.J., Head of Physics Department, Boston College.
11:30 Address: Nutrition and National Defense: Dr. Helen Mitchell, Chief Nutritionist, Federal Security Agency.
12:30 Luncheon.

AFTERNOON PROGRAM

2:00 Meeting of the Executive Committee.
2:15 Business Meeting.
2:30 Address: High Explosives: Mr. Charles Kenney, Boston School Department.

OFFICERS:

President: John P. Brennan, High School, Somerville, Mass.
Vice-President: Clarence W. Lombard, High School, Hyde Park, Mass.
Secretary: Carl W. Staples, High School, Chelsea, Mass.
Treasurer: Preston W. Smith, 208 Harvard Street, Dorchester, Mass.

EXECUTIVE COMMITTEE:

Everett, J. Ford, English High School, Boston, Mass.
Lawrence A. Howard, High School, East Boston, Mass.
Robert W. Perry, High School, Malden, Mass.

Business Meeting

Mr. Elbert C. Weaver of Bulkeley High School, Hartford, Connecticut was elected to active membership.

The New Physics Syllabus

This syllabus was recently adopted by the College Entrance Examination Board and is in effect for the June, 1942 Examination.

The syllabus consists of Part I, topics upon which the examination will be based, and Part II, recommended and enrichment topics on which no questions will appear in the examination. Many topics formerly required now appear in Part II. The following topics have disappeared entirely from the syllabus:

Specific gravity of solids lighter than water.
Volume expansion of solids and liquids (quantitative).
Heat engines, steam and gas.
Shadows (and presumably eclipses).
Condenser.
Resistance box.
Methods of measuring resistance except voltmeter-ammeter method.
Electric bell, telegraph.
Arc lamp.
Induction coil.
Telephone.

The following topics or expressions have been added:

Hooke's law.
Weight-density.
Kinetic-molecular conception of matter; qualitative evidence.
Ideal mechanical advantage.
Torque.
Vectors.
More emphasis upon wave theory.
Total internal reflection and critical angle.
Visible region only, in spectrum.
Projection lantern.
Erving theory of molecular magnets.
Potential difference.
Relation between watt-second and calory.

FRED R. MILLER, *Chairman*
Committee on College Entrance Syllabus

REPORT OF CHAIRMAN OF NEW APPARATUS COMMITTEE

The priorities situation involving scientific apparatus is the most interesting question of the moment. It appears that educational institutions have no such thing as "automatic priority" in the obtaining of equipment but each one desiring to purchase such equipment must establish its need and obtain a rating if it is to received a preference. Thus a laboratory doing the training of workers in testing of metals, these workers thus being able to go directly into defence work, will readily obtain high priority rating in the purchase of its equipment, while our high school laboratories will have to take what is left.

As a matter of fact, however, the holding of a favorable priority rating is no guarantee of prompt obtaining of scientific equipment. A company making equipment cannot buy metals to make equipment until it obtains a suitable order backed by proper priority number, and then is entitled to buy only enough metal to fill *that one* order. A firm cannot economically manufacture one single article, and hence must wait until it has enough back log of orders to set and manufacture the articles.

My recommendation is that (1) we cooperate in every way possible with the governmental restrictions in regard to equipment and that (2) we endeavor to build for ourselves even more equipment than we have in

the past. I hope that our other meetings this year will see much new equipment exhibited by members of the association.

EDWARD B. COOPER, *Chairman*

COSMIC RAYS

Address by REV. JOHN A. TOBIN, S.J.

The discovery of cosmic radiation is a great tribute to the scientific method of observations, measurements, and logical reasoning. In all branches of science we try to train the student to observe the variations, measure the constants, and reason by induction to the laws of science. If the facts are not true, then all the good logic in the world cannot give a true conclusion. When the logic is faulty then all the good experiments and measurements cannot reach a true conclusion. The history of the discovery of cosmic rays gives us many examples of false conclusions that came from false facts and good logic, or from false logic and good experiments. In the history of cosmic rays one error came from stating a universal law from a small number of experiments. Within the limits of induction we may affirm or deny that which was affirmed or denied about the particulars under this universal subject. This was called the "Argument from Experience." The difficulty is practical rather than logical. The logical process is abstraction. A constant effect demands a constant cause. When we find the quality that is indispensable in causing the effects, it is not difficult to make the law. But the practical difficulty is the experimental elimination of all the other factors that do not cause the change. The history of the discovery of cosmic rays proves that this elimination is no easy matter. The great complexity of the order and the difficulty of making accurate observations offered many difficulties.

To understand what we mean by cosmic rays and what we mean by the difficulties of logical reasoning from the measurements it is helpful to know the history of the discovery, the four types of instruments that were used to measure the rays and the results obtained in these measurements.

The discovery of X-Rays in 1895 by Roentgen prepared the way for the discovery of radioactivity by Bequerel. In 1898 the Curies discovered radium. It was soon observed that the positive particles or alpha rays, and the negative particles or beta rays, or the radiations like X-Rays or gamma rays all had the common property of making gases electrically conductive. Ions of positive and negative electricity were formed in the gas and moved in opposite directions in an electric field. This current could be measured and the number of ion pairs formed per second in each cubic centimeter (q) could be determined. This gave the total intensity of all radiations coming into the ionization chamber. At first this was considered as caused by radioactive substances. But in 1901 C. T. R. Wilson in England, and Elster and Geitel in Germany proved that the stagnant air in a dustproof sealed vessel had the property of conducting electricity. So the cause of ionization

was not the air in the vessel, as the radon and its decay products die out in time used to hold the air. Some other source than the enclosed air must be the cause. Three other sources were then known. The earth had radioactive substances, the metal of the ionization chamber had these radioactive substances and the air surrounding the chamber had these same substances. In 1903 Rutherford and Cooke, and McLennan and Burton in Canada observed that 30% of the ionization was cut off by a thickness of a lead screen of two inches. The air and the earth were removed as causes by making the measurements over the ocean. In 1905 A. S. Eve in Canada stated that the small amount of radioactive substances in the air would not be sufficient to account for the ionization found over water. From his measurements he computed that the radioactive substance in the air could only produce one-tenth of the effect produced over the water. If we represent the total ionization as q and the ionization caused by the earth as q_e and the ionization caused by the air as q_a and the residual ionization caused from impurities in the metal as q_0 then the equation read $q=q_a+q_e+q_0$ but there was still another amount called q_c. For example you find ten dollars in the cash drawer. In making out the accounts you find that there was three dollars (q_0) in the drawer for cash, one sale was four dollars (q_e) and another sale was one dollar (q_a). But there are still two dollars to be accounted for. This was the problem that Fr. Theodore Wulf, S.J. tried to solve. What was the cause of this ionization that did not come from the earth, the air or the metal. For example the capacity (c) of the apparatus was 34.6 cm. The volume (w) was 27,000 cc. Fr. Wulf used his own electrometer, but using a Lindemann electrometer the time (t) to pass five divisions (n) was found to be 89.7 secs. and the value of each division (s) was calibrated as 46 divisions per volt. From the general equation the value of total ionization was determined.

$$qew=\frac{c}{300}\times\frac{dV}{dt}\cdot \quad \text{But}\ \frac{dV}{dt}=\frac{n}{s\times t}=\frac{\text{volts}}{\text{per sec.}}\cdot$$

$$\therefore\quad q=\frac{1}{ew}\times\frac{c}{300}\times\frac{n}{s\times t}\quad\text{or}\quad q=\frac{1}{4.8\times10^{-10}\times27{,}000}\times\frac{34.6}{300}\times\frac{5}{46\times89.7}=5.4I.$$

In 1910 Fr. Wulf determined the ionization at the foot of the Eiffel Tower, after subtracting the residual as six Ion pairs per sec. per cc. or ($6I$). At the top of the Eiffel Tower he found 3.5 I where there should have been none, as the air should have absorbed the radiations from the earth. Fr. Wulf constructed his own apparatus and his own electrometer. He observed and measured. Then he reasoned logically that either there was another source of radiation in the upper atmosphere or the absorption of gamma rays by the air was smaller than given at that time.

Dr. Victor F. Hess, now Professor of Physics at Fordham University, and Nobel Prize winner in 1936 for the discovery of cosmic rays, writes, "After reading the account of Fr. Wulf's experiment, I decided to attack the problem by direct experiments of my own." Dr. Hess removed the second suggestion of Fr. Wulf by measuring the absorption of gamma rays in the air

and found that they were completely absorbed in 500 meters of air. So then Dr. Hess tested the second conclusion. He made ten balloon flights and found the following interesting facts. At 500 meters altitude there were $2I$ less than on the ground, at 1500 the same as on the ground, at 3500 there were $4I$ more than on the ground and at 5000 there were $16I$ more than on the ground. In 1912 Dr. Hess concluded that the observed effect could only be interpreted by assuming that a very penetrating radiation of extra-terrestrial origin exists. He called them "Weltraumstrahlung." A. Gockel in Switzerland had made three flights with Fr. Wulf's electrometer but instrumental errors had masked the results. The practical difficulty of removing sources of errors was studied and in 1913 and 1914 Kohlhoerster went up to 9300 meters and verified the observations of Dr. Hess. Since that time many measurements have been made and they are so clear that reason demands some new and very penetrating radiation that comes from the ground. Here we can note from the altitude effect a bit of poor logic. Millikan and Bowen in Texas noted this altitude effect but their measurements were different from Dr. Hess. The conclusion that Dr. Hess was wrong was not true. In 1930 J. Clay observed a new effect, the latitude effect. So both measurements were correct for their own latitude. Another false induction was noticed at this time. Observers who measured the intensity from 40° to 80° North did not observe the latitude change. Their conclusion that there was no latitude effect was false. It is noticed from 40° to the equator. The World War stopped the work but in 1925 Millikan and Cameron proved from their observations at great depths in snow-fed lakes that these rays are very penetrating. In 1932 both Compton and Millikan made a study of these rays all over the earth and verified the altitude and latitude effects. As the rays were deflected in the earth's magnetic field as noticed in the east-west asymmetry effects it was reasoned that they must consist mostly of charged particles that would be deflected into these fields. These facts removed some of the false conclusions that came from very fine logic but on the foundation that the rays were electromagnetic radiations. It is now universally admitted that these particles originate outside the earth's atmosphere. When we realize the practical difficulties of removing 80% of the radiation that comes from the earth and the instruments, and the great difficulties of measuring the cosmic rays at high altitudes, then in deep mines and then in the open ocean, and the work of coordinating results all over the world, it is interesting to note how the instruments proved the logical conclusion of Fr. Wulf that there was a new radiation of greater energy and penetration than we have on earth.

There were four methods used in the experiments on cosmic rays. The first was the ionization chamber and electroscope. The discharge method allows the current to leak off from the charged electrometer. In the charge method there is a flow to the electrometer. To avoid large chambers the small chamber is used at high pressures. To avoid recombination as much as possible argon gas is used. Compton used three concentric lead shells to cut out the radiations from the earth. In high altitude work this lead shield

is not necessary as the air absorbs the rays from the earth. This instrument gives the intensity of ionization but not the number of rays or the nature of the rays.

The direction of the rays and the number of rays are determined by the counter telescopes. A single Geiger-Miller counter responds to rays in all directions. But when three counters or more in a line are actuated simultaneously, and the pulses from these counters are fed into a recording system that *only* registers when *all three* are actuated simultaneously then the direction of the counter shows the direction of the rays. As only cosmic rays have the energies to pass through all the counters, the counter telescope does not respond to any other rays, and we can measure the number of the rays. The Geiger-Miller counter consists of a Pyrex glass tube containing a copper cylinder about 20 cm. long and 1 cm. in diameter. This copper cylinder is connected to the negative terminal of a high potential of about a thousand volts. Through the center of the cylinder runs a small tungsten wire that is connected to the positive of the high potential through a high resistance (10^8 ohms). The electrodes are held in place by a glass envelope that is sealed when filled with a mixture of 94% Argon and 6% Oxygen at a pressure of a tenth of an atmosphere. The passage of a cosmic ray causes ions in the counter, and these ions collide and cause other ions and precipitate a discharge across the electrodes. The negative ions move to the positive thin wire and cause an excess of electrons on the condenser plate in series with it. The other plate becomes positive and makes the grid of a 57 tube negative. The pulse through this tube is then amplified by the usual methods. The discharge in the counter tube is not continuous but intermittent. When the counter is exposed to known and constant sources of radiation and the number of pulses are plotted against the applied voltage, the curve shows the threshold voltage, the plateau voltage where the counting rate is independent of the voltage, and the glow discharge. The tube is operated at some voltage in the plateau voltage region. If a cosmic ray should actuate the tube at the instant that the tube is recovering, or in the time that the recording device is recovering there is a source of error. This error is corrected by the Laws of Probability. Another error could creep in from the chance that three different rays from three different directions could actuate the three counters simultaneously. To avoid this error, duplicate sets of counters are placed in the walls and so connected that the recording apparatus does not register when these independent rays actuate the counters. These cosmic rays telescopes proved that cosmic rays were electrically charged particles, as photons could not actuate the three counters simultaneously. By these telescopes the altitude and latitude effects were studied. A beam of particles is like an electric current, and a current in a magnetic field has a thrust on it the same as the thrust on the wire in the armature of a motor. As the rays that are bent in the magnetic field of the earth have to pass through more atmosphere, they are absorbed near sea level. It is found that the intensity is 10% greater at Vancouver than at the equator. Since more rays move perpendicularly to

the earth's magnetic field at the equator than anywhere else, fewer charged particles should get through in that region, and Clay found the decrease from 40°S to the equator and likewise 40°N to the equator. At an altitude of 40,000 feet however Swann and Locher of the Barthol Research Foundation found many rays that were horizontal. These counters then tell us the direction of the rays and their number.

The third method is used to study the nature of these rays. The Wilson cloud chamber makes visible the ion path by means of droplets that condense around the ions. When the cloud chamber is placed in a strong magnetic field the particles are bent into curved paths according to the nature of their charge and their mass. Anderson detected the positron as it had the same mass as the electron but an opposite charge. The energies of these cosmic rays were studied as the energy in electron volts could be measured by the product of 300 times the radius of curvature and the strength of the magnetic field. A most interesting combination of counters and a cloud chamber was used to study cosmic rays. If a cosmic ray actuated the counters above and below the cloud chamber, then that ray could be photographed in the cloud chamber. The pulse in the counters was used to actuate the plunger in the cloud chamber and also at the proper time to photograph the tracks that were visible. In this way there were pictures of cloud tracks on the film. In these pictures the cosmic ray showers were studied and the existence of a particle that was 200 times heavier than the electron was discovered. These particles called mesotrons have great penetrating power. This third method gives facts about the nature and the energies of these particles.

The fourth method was developed by Wilkins in Rochester. He made a study of tracks in the silver bromide of photographic plates. By determining the grain spacing and the number of particles per cc. that have been blackened by the path of the cosmic rays, he determined the types of particles and their energies. This method verified the results about the nature of the particles studied in the cloud chambers.

From the history of the discovery of cosmic rays and the use of the above four methods in the measurements, we have the following results. The intensity of these rays vary with the altitude. These rays also vary with latitude. There is the east-west asymmetry of 10% more positives than negatives. The intensity varies with changes of pressure and changes of temperature. There is a monthly change which indicates a 27.9 day period. There is a daily period with a maximum at noontime. Then there are variations due to magnetic storms. There is need of more experimental evidence for a complete induction about these daily, monthly, and irregular variations of cosmic ray intensity. It can be understood from articles in the *Physics Review* for 1941 (e.g. Oct. 15) how our knowledge of these variations is still incomplete.

Not only these variations in intensity, but the nature of the particles have been studied in the last ten years. Rossi in 1932 showed an arrangement of three counters in a vertical plane with as much as a meter of lead

between them that about 40% of the charged particles coming down vertically at sea level are able to penetrate through this material. These must be particles as photons cannot pass through. When cloud chambers were interposed between the thicknesses of lead these cloud chambers operated by the coincident pulses from the counters the density of ionization showed the paths to be those of fast and penetrating electrons. The mass of some of the particles was found to be two hundred times that of the electron. These particles were called mesotrons. The Rossi curves showed a maximum of counts through about two centimeters of lead. As the thickness increased the number of counts then decreased. This hump in the curve is also noted in the altitude intensity curves. So besides the penetrating particles there are less penetrating ones. From these particles come showers that were photographed. The counters can be arranged so that a photon cannot cause the pulse in the first counters and we know the showers are charged particles. This cascade process can be explained by the *primary* electron striking non-radioactive matter and sending out a *primary* photon as in the x-ray tube. Then this primary photon in striking an atom sends out an electron pair. These *secondary* electrons of the pair can cause *secondary* photons. These *secondary* photons then produce the *tertiary* electrons in pairs. The low energy of these electrons dies out in collision and they are easily absorbed. This low energy part of the cosmic rays explains the hump on the Rossi curves and the increase in ionization due to altitude up to 16 kilometers and then the decrease. The high energy electrons entering the atmosphere cause this shower effect and the increase in the intensity. However after the equivalent of 2 cm. of lead the thickness of the atmosphere absorbs these low energy electrons and the intensity decreases down to sea level. Many false conclusions came from the study of these low energy electrons that come from the showers. If you merely study this part of the energy spectrum then the incomplete induction about the nature of cosmic rays is clear, as the penetrating electrons and mesotrons are omitted.

From photographs in the Wilson cloud chambers we find that the earth is being bombarded by high energy particles that measure up to 20 billion volts. This is a thousand times higher than any source that we have on earth. Hundreds of these particles go through our heads every minute. A particle that has an average energy of a billion electron volts will pass through a thickness of 10 cm. of lead in a straight line. These particles have unit charges, are almost equally divided, with a slight excess of positives. Protons have a mass 2000 times that of the electron and neutrons have this same mass but are not deflected in the magnetic field. These neutrons are detected when they bombard parafine and send out alpha particles that ionize. This gives us the cosmic ray family of electrons and positrons of small mass, mesotrons of intermediate mass, and protons and neutrons of large mass. At present the great work is to study the energy of these particles. Mesotrons are not stable and have a mean life time of 2 microseconds or one-millionth of a second.

From the history of cosmic rays we see how the careful measurements of Fr. Wulf, S.J. and his logical conclusion that some other agency then unknown must have been the cause, and the careful work of Dr. Hess in searching for this unknown cause of ionization led to the great work in this study. It is an object lesson in both the scientific method and logic. The difficulty was practical. Nature only whispers her secrets and the scientist must listen carefully and realize that his mind is finite and must be humble and not generalize from some few facts. We do not know how these high energy particles are sent out, and we do not know where they come from in the universe except it must be far out in space and free from matter.

(The above lecture was illustrated by many slides)

WARTIME GASES

Address by LOUIS R. WELCH

I find myself today in the unique position of a speaker who sincerely hopes that his talk will never be of any practical use to his audience.

The scientific aspects of modern warfare have never been given much consideration in our secondary school classes. We understood that there was to be no more war. Consequently, the curriculum makers and the textbook writers made little mention of the military or naval applications of scientific principles. It was felt that these would be of little interest or value to boys or girls of high school age.

Now all is changing. World history, in the making during the past two years, is forcing us to revise many of our cherished ideas. Many authorities now ruefully admit that it has become expedient for our high school students—for all civilians of all ages—to receive at least a basic training in certain fundamental defence measures against possible aerial attacks.

The part of this training that has to do with gas warfare is of great importance. People as a whole know least about this type of fighting and look upon it with undue fear and horror. As a result of this ingrained fear, the use of gas upon untrained troops or civilians, quickly lowers their morale to the verge of panic. This is not true with trained groups who realize that with proper precautions the number of casualties resulting from a gas attack will be surprisingly low. The science teacher should be able to answer intelligently questions concerning gas, to take the mystery away from gas attacks, and to dispell much of the horror with which gas fighting is viewed. It is not necessary or advisable that this instruction be of a highly technical nature. Formulas or scientific names need not be stressed or even mentioned. It is merely necessary in such a basic course, to consider the general characteristics of gases likely to be encountered, to outline the necessary protective measures, and to indicate the proper treatment for gas casualties.

Next to actual experience on the firing line, the best method of studying a weapon is to learn how it has been used and how it has been combatted in the past. The use of gas as an offensive or defensive weapon was first discussed at the Hague Peace Conference of 1899. It may be surprising to learn that the United States at this conference, argued against the prohibition of gas in warfare. Our representatives argued that gas is no more attrocious, inhuman, or brutal, than many other recognized weapons. In fact there are many instances, such as rear guard actions, where the use of gas would accomplish the necessary objective just as efficiently and more humanely than buried land mines, high explosive bombs, or the cold steel of the bayonet. At any rate all the other great powers signed a clause which made it contrary to International Military Law to use any projectile "whose sole purpose is the dissemination of a harmful gas." The United States has never signed this agreement.

The first actual gas attack, laid down in front of Ypres on April 22, 1915, by liberation of dense clouds of chlorine gas from cylinders, was met by the expedient of using wet handkerchiefs as inprovised gas masks.

The Germans claimed that they had not violated the article prohibiting the use of a projectile to disseminate a harmful gas because they had merely liberated the gas from cylinders. Later the English and French, after developing gas shells, also naïvely claimed innocence under International Military Law. They claimed some conceivably, might be hit on the head with one of these shells and, consequently, its *sole* purpose was not the dissemination of a harmful gas.

Both armies immediately tested great numbers of gases for their potential offensive value. Out of 3000 investigations 30 were considered suitable, 12 were given a trial, and a mere half dozen proved successful. In order to be suitable for warfare purposes a gas must possess six very definite characteristics. It must not react readily with iron. Such a reaction would make it impossible to store the gas in cylinders or compress it inside shell casings. The gas must have the ability to withstand great heat and pressure. A gas lacking this ability would be chemically changed by the force of the exploding charge in the gas shell. It must not be affected by water or its effectiveness over any given area could be easily reduced. It must be difficult to detect or it becomes a simple matter for the victims of a gas attack to take the necessary precautions in time. It is necessary that the gas have a low intolerable limit. Unless a lethal concentration can be built up against troops in less than two minutes any further concentration is useless. Two minutes is ample time for trained persons, even if caught unawares, to take the proper protective measures. Finally the gas must have the proper persistency. A persistent gas is classified as one that remains in the vicinity of its liberation for at least ten minutes.

The first toxic gases used to any great extent in the World War were the lacrimators or tear gases. Gas shells were not yet developed. Since the gas was tossed over in hand grenades or rifle grenades only a non-persistent gas could be used. The limited range of these grenades made it impossible

to use a gas which might remain over the very area soon to be occupied by the troops originally launching the gas attack.

These lacrimators, although non-persistent and non-lethal, were effective enough in extremely small quantities to knock a man temporarily out of action. Their effects were almost instantaneous but the use of the gas-mask gave perfect protection. The main tactical use of these lacrimatory agents was to harass the enemy, force him to wear his mask constantly, and reduce his mental and physical efficiency. Because of their non-persistency, their inability to penetrate the gas-mask, and their non-lethal characteristics it is not probable that such agents will ever be dropped on civilian populations.

Brombenzylcyanide was the most powerful lacrimator of the last war. Developed by the French, it had the odor of sour fruit, was almost invisible, and produced a severe burning sensation in the eyes and mucous membranes. Chloracetophenone, developed by the United States, but not used in the last war, was a solid and resistant to both heat and water. It smelled like apple-blossoms, and in addition to the lacrimatory and irritating effects of brombenzylcyanide it produced a skin burn similar to sunburn.

Victims of tear gas need not be evacuated. They should merely face into the wind allowing it to blow into the eyes. Clothing should be loosened to rid it of any trapped gas. In severe cases the eyes may be bathed with cold water or dilute solutions of boric acid or of baking soda. If a bubbler drinking fountain is available, as would be probable in a peace-time accident this makes an excellent device for flushing the gas, or other chemicals from the eyes.

The largest number of injuries in the last war were caused by lung irritants. These were classified either as simple lung irritants or systemic poisons. The simple lung irritants were derived from chlorine, and affected the organs of the respiratory system only. They attacked the lining of the lungs causing serum to exude from the blood into the air-sacs and block the passage of air into the pulmonary veins. Death similar to drowning might result or infections leading to bronchitis or pneumonia developed.

Systemic poisons or nerve gases were derived from arsenic. These penetrated the lining of the lungs and passed into the blood stream to cause a general body poisoning or death from paralysis of the central nervous system. These so-called nerve gases were very non-persistent and non-effective until a certain critical concentration was reached. These gases also seemed to be highly affected by shock and pressure and consequently their employment was limited.

Chlorine, the lung irritant first used by the Germans, caused choking, coughing, smarting of the eyes, and pains in the chest. This gas, due to its characteristic color and odor, was easily detected. The gas mask offered perfect protection; but the soldiers, quickly losing their initial fears, were apt to be careless or slow in adjusting their masks.

Phosgene, the second lethal gas of the war, was developed by the Ger-

mans in 1915. This deadly combination of chlorine and carbon monoxide became the principal gas of the allies and caused 80% of the gas casualties. It had a pleasant odor like new-mown hay, but one or two breaths were deadly. It was not nearly as irritating to the nose and throat as chlorine. Hence, men were likely to breathe more of this gas than they would of chlorine.

With the men of both sides now realizing the necessity of immediate protection and with masks available to furnish this protection, the first deadlock in gas warfare was reached. Chlorpicrin was developed to break this deadlock. It was a pungent gas with a sweetish odor resembling sticky flypaper. It was able to penetrate the early mask cannister, but a special type of carbon, made from peach stones and cocoanut shells, was soon produced which could stop this new gas. Chlorpicrin was not as lethal as phosgene, but if small quantities were inhaled it produced nausea, vomiting, diarrhea, and other digestive disorders. An untrained soldier would then remove his gas mask, and fall victim to the more deadly phosgene which was sent against him at the same time. These effects lasted for a considerable time and this gas caused heavy casualties.

It is absolutely necessary that the oxygen requirement for victims of lung irritant gases should be kept at a minimum. They should be absolute stretcher cases even though showing at first little effects from the gas. The victim should be removed from the contaminated area. His clothing should be entirely removed. He should be wrapped in blankets to keep him warm and by no means be allowed any muscular exertion.

After two years of gas warfare both sides had developed masks giving protection against all types of war gases. All soldiers had learned the necessity of the proper care and adjustment of gas masks. So gas again became looked upon more as a nuisance than a menace. The Germans again attempted to break the deadlock by developing vesicant or blister gases. These substances were capable of causing large and painful blisters on any exposed skin. Under many conditions they could also penetrate clothing or shoes to sear the flesh and incapacitate the victim. Over 70 such vesicants are known. Of these mustard gas and Lewisite are the most efficient.

Mustard gas, used first in 1917, is an oily liquid which changes to an irritating gas at relatively low temperatures. It derived its name from its biting odor which resembled garlic or horse-radish. It was usually sprayed as a liquid from airplane bombs, or artillery shells, at night. It vaporized in the heat of the following day to form its invisible treacherous clouds, lurking in low places to trap unsuspecting victims. As a gas it produced all the symptoms attributed to lung irritants. As a liquid it was able to penetrate shoes and clothing, producing red and inflamed areas on the skin, which rapidly developed into extremely painful blisters.

Lewisite, developed by Dr. Lewis of the U. S., in 1917, has never been used in warfare. The first lot was ready for shipment when the armistice was signed, but was dumped into the sea. It combines the vesicant action of mustard gas with the systemic poisoning of arsenic compounds. In

addition to its irritating effects on the eyes and lungs it produces a grayish discoloration and severe skin blisters in about 30 minutes after exposure.

All agents classified as vesicants have also powerful eye and lung irritant action. Victims should be removed at once from the contaminated area. All clothing should be removed. If the face has been exposed the eyes should be washed, and the nose and throat rinsed with strong boric acid or weak baking soda or common salt solution, If the vapor has been breathed the victim is treated as a lung irritant casualty. First aid must be prompt. Little can be done later than a half hour after exposure. Vapor burns on the skin may be lessened by or even prevented by thoroughly cleasing with hot soap and water. For Lewisite burns use a 5% solution of sodium hydroxide.

Toward the close of the war an irritant type of smoke was developed known as a sternutator. These smokes caused few casualties, but were able to penetrate the slightest opening in or around the mask, this caused violent vomiting. The soldier, if he removed his mask, fell victim to lung irritants or vesicants fired over at the same time. Sneeze gas, a grayish smoke with the odor of black gunpowder; and Adamsite, a yellow smoke smelling like coalsmoke were the most notable examples of this class.

Victims of these smokes may require evacuation. They must be kept away from heat, their clothing removed, and the nose and throat flushed with sodium bicarbonate or salt solution. It helps to breathe a low-concentrated solution of chlorine, from a bottle of chloride of lime, and to wash any exposed surface of the body with soap and water.

Another type of attack, designed to produce a dense smoke and hamper rescue or fire-fighting activities, might be encountered in a bombing attack. White phosphorus makes the most efficient and deadly screening smoke. Powdered phosphorus produces a white choking smoke interspersed with yellow bits of flame on exposure to the air. The smoke is harmless but the solid particles of phosphorus cause severe slowly healing burns.

This type of burn should be covered with water to stop the action, and the solid particles picked from the flesh. Wet cloths, mud or damp earth may be used if water is not handy. Since phosphorus melts at 110°F. hot water will more readily remove the melted particles. Prompt application of a 2–3% solution of copper sulphate will form a thin coating of copper phosphide over the phosphorus. This will stop the burning action at once and the particles may be easily removed from the flesh. The copper sulphate should be applied by soaking a swab in the solution and placing it on the particles. After removal of the phosphorus, the burns should be treated and dressed.

The point, then, to be emphasized in this training is that gas is just another weapon, like tanks, airplanes, and submarines. It can be deadly and treacherous, but, like these weapons, it has been met before and stopped before. Finally, with the proper training and cooperation it will be met and stopped if it is ever used again.

HIGH EXPLOSIVE BOMBS

Address by CHARLES B. KENNEY

One of the greatest problems confronting the authorities in charge of our civilian defence program is the general apathy with which the general public looks upon its efforts. As an instructor in air raid precaution work for the Boston Committee on Public Safety, it is not my purpose to convert you into zealous air raid instructors or to convince you of the probability that air raids will take place here in New England. Instead, I should consider my mission successful if some of you leave this room thinking seriously of the solution of the many problems which my talk will suggest.

Much has been written in the papers during the past two years about the horrors of an aerial gas attack and about the havoc wrought by large scale incendiary bombings. That the former case is highly improbable because of its impracticability was duly stressed in this morning's lecture. The latter possibility, too, is a danger of lesser order. Given a sufficient number of spotters to detect the fall of incendiaries and a civilian population adequately trained in the technique of handling them, your dreaded thermite bombs are no more dangerous than so many burning wastebaskets, *provided they are attacked in the early stages*. But, despite the publicity given to the air raid shelters of London, no satisfactory protection has as yet been devised against high explosive bombs rained down from the sky upon civil populations. The fact that civilian casualties in this war have far out-stripped military casualties is proof sufficient of this.

We may well define a high explosive bomb as one consisting of a charge of high explosive powder contained in a steel case fitted with one or more fuses and an exploder. The fuses may be timed to explode at the moment of impact, in which case they are called "instantaneous" fuses. Bombs with such fuses must be cropped from a rather high altitude to avoid considerable damage to and possible destruction of, the planes doing the bombing. Again, the fuses may be set to explode the bomb within a minute after its impact so that the planes may swoop low for accuracy and yet get out of range of the ensuing explosion. Bombs equipped with such fuses are called "short-delay" bombs. Finally fuses may be set to detonate the charge as much as 100 hours after the impact. These may be dropped from high or low altitudes and are called "long-delay," or "time" bombs.

The main charge of a high explosive bomb is an insensitive high explosive such as TNT. In order to detonate this charge at the proper time and with the proper order of detonation the following sequence of events must take place. First, a primer must be actuated. In the case of an instantaneous bomb the force of impact pushes a needle into a tube of mercury fulminate causing it to detonate, and in turn to detonate the main charge of the bomb. In the case of a delay bomb the primer, which may be of the same type used in a shot-gun shell, ignites a compressed black powder train which burns slowly. This ignites a small relay charge of mercury fulminate, which, in turn, ignites a detonator having a probable combination

of mercury fulminate and tetryl. This detonator ignites a booster of tetryl or picric acid which finally detonates the bomb charge.

Before considering the main types of bombs and their various destructive effects it may be well for us to consider something of the nature of the main charge of the bomb. In general an explosive is a substance, usually a solid, which when subjected to heat or shock, or both, is converted almost instantly into a very much greater volume of gas at a very high temperature and pressure. This gas expands and breaks the bomb casing with a force that depends on the volume of gas per unit weight of powder and the rate at which the solid becomes a gas. Sometimes the conversion takes place as the result of a rapid combustion process. The rate of conversion in this case is relatively low as compared to the rate of detonation in a high explosive, and so it is usually called a low explosive. Its characteristic effect is that of a push whereas that of a high explosive is that it shatters.

The destructive power of a high explosive bomb is the result of its several effects which occur in approximately the following sequence:—(1) impact; (2) penetration; (3) blast; (4) fragmentation; (5) cratering; and, (6) mining effect. We shall discuss each of these briefly.

When a falling bomb lands upon a target its first effect is to put a tremendous load upon its surface due to the retardation of the bomb by the resisting medium. The extent of this stress depends upon the kinetic energy of the bomb and hence can be computed by the familiar formula

$$K=\frac{WV^2}{2g}.$$

When we realize that a small 660 lb. bomb dropped from an altitude of 25,000 feet will attain as its maximum velocity a speed of about 1000 ft. per second and that substituting this value in this formula will produce an answer greater than 10,000,000 ft. lbs., we can get some conception of the damage due to the impact of the bomb alone.

The destruction caused by a high explosive bomb depends to a considerable degree upon the depth to which it penetrates its target. One reason for this is that when a bomb penetrates its target its impact and explosive effects are cumulative. Of more importance is the fact that the explosive gases are more confined when penetration has taken place and hence have much greater disruptive effect. It is important to note that, if the target is backed up by a supporting medium such as earth, a large part of the compression will be absorbed by the supporting medium thus reducing the stresses and strains within the target and thereby lessening the extent of penetration.

When a high explosive in a bomb detonates, each cubic inch of solid is converted into 1000 cubic inches of gas at normal temperature. The heat of the explosion, however, continues the expansion process until it has increased ten-fold. Hence, we see that each cubic inch of solid is converted into approximately 10,000 cubic inches of gas. This results in terrific pressure against the walls of the bomb case (about 500 tons per square inch).

As a result of this pressure the steel case swells to one and one-half times its normal size, at which time the metal fractures and releases the compressed gas into the air. The sudden compression of the air which ensues is known as the blast effect of the bomb. The initial velocity of this blast is somewhere in the vicinity of 5000 miles per hour. Although this velocity diminishes rapidly to the speed of sound (within a radius of 25 feet), it is an unexplainable fact that much greater damage is often done along the circumference of a circle of quarter mile radius than at the very center of the explosion.

The sudden rushing out of the gases when the bomb explodes creates a vacuum, and hence an important part of the blast effect is the suction effect which accompanies it. While this is of less intensity than the blast itself, being between six and seven hundred miles an hour, it lasts about five times as long and so is very often much more destructive. Our knowledge of the tremendous destruction wrought by the hurricane in 1938, in which the wind attained a velocity of some one hundred miles per hour, gives us some conception of the damage which can be done by the suction effect accompanying an exploding bomb.

Simultaneous with the blast effect is the process of fragmentation. When the steel case of the bomb bursts, it shatters into thousands of small irregularly shaped pieces which are heated to high temperature by the explosion and projected radially at twice the speed of a rifle bullet. These fragments are approximately an inch thick and will kill and wound at distances up to half a mile. In addition, when they strike wood, they may penetrate as far as five inches and have a very definite incendiary action. However, the blast effect is much more destructive to life and property within its quarter mile range.

The hole created by a falling bomb is known as its crater. Because of the tendency to build up a rim around the circumference of this hole, this cratering effect produces a rough sort of mortar which tends to project the blast and fragmentation effects of the explosion upward in the shape of a cone. Because of this fact persons on the ground or in trenches close to an exploding bomb often escape unharmed while others farther away suffer injury or death.

A bomb exploding within a solid medium transmits pressure waves through the medium and displaces it around the crater. We call this process the mining effect of the bomb. It is quite important because it can cause buildings to topple by destroying their foundations and can interfere seriously with water, gas, and electric mains. Fortunately, even the very large bombs will not do great damage for any considerable lateral distance under ground.

Now that we have dissected an explosion process that occurs in about thirty thousandths of a second and considered its various effects, let us now consider some of the bombs in common use today. There are three main types of high explosive bombs, namely:—(1) the demolition bomb; (2) the general purpose bomb; and, (3) the fragmentation bomb.

As its name implies, the demolition bomb is intended to demolish targets. It has a hard, heavy steel case, usually forged from one piece but sometimes produced by careful welding. The temper and weight of the case varies according to the strength of the material to be penetrated. It is equipped with short-delay and long delay fuses and has four comparatively large fins to guide it to its target. Its powder content varies from about ten per cent in the armor-piercing type to about fifty per cent in the largest specimens. Its size ranges from about 660 lbs. to 4000 lbs. Since a plane can carry but one of the latter monsters, they are used only for special targets of great size and strength such as large bridges, canal locks, dams, etc. As a consequence, bombs weighing from 660 lbs. to 1100 lbs. are much more commonly used.

The general purpose bomb is one which differs but slightly from the demolition bomb. Since it is not intended to penetrate to great depths, its case is of medium thickness and its powder content varies from forty to sixty percent of its weight. It ranges from 50 to 550 lbs. and is equipped with instantaneous and short-delay fuses. In the event of a direct hit or a near hit, it can do considerable damage to protected buildings and will utterly demolish unprotected buildings in either case. Since a plane can carry many more general purpose bombs than those of the demolition type and since the former are more effective in the event of a near hit, they are the ones most commonly used.

The fragmentation bomb is a comparatively light affair weighing from 22 to 55 lbs. and having a very low ratio of high explosive charge. Its case is very light and it is equipped with an instantaneous fuse. Upon detonation it scatters thousands of metal fragments over a very wide area. Their power to kill and maim as well as their incendiary effect has been mentioned earlier. Because of the penetrating power of these fragments, the fragmentation bomb is effectively used against truck convoys and grounded planes. Inasmuch as this type bomb is used almost exclusively against military forces in the field it is often referred to as the "Anti-personnel" bomb.

Before closing we shall mention a few random facts concerning some of the bombs that have been dropped on England. One of the largest ever discovered there was a 4000 lb. time bomb some twelve feet in length. It was taken from a hole some fifty feet deep. This fact rather upsets any plans we might have of using our shallow subway systems as effective shelters in the event of air raids.

Although 2200 lb. bombs are common than such monsters, bombs from 1100 lbs. downward are used most of all. The 1100 lb. kind is six feet tall and 18½ inches in diameter. A grown man would easily fit inside it while an ordinary one-family house would fit quite comfortably in its crater. Its smaller brothers, the 660 lb. and 550 lb. bombs are about five feet high and 14½ inches in diameter. Your boy in his early teens would fit in one, and your one-car garage would be engulfed in its crater. Incidentally, if one of these so-called medium bombs, even though it be the lighter general pur-

pose 550 lb. kind, were to hit a modern concrete building directly, it could penetrate through six floors of reinforced concrete of six inch thickness. Were it to land outside such a building, the first six floors would be rather unhealthy places for those desiring a long life. However, if such a building were more than twelve stories high, its inside corridors on the middle floors would constitute an excellent place of refuge.

Because of the depth to which a bomb may penetrate and the possibility of being inundated by water from broken water mains, not to mention the remote possibility of the use of gas, underground shelters are not looked upon too favorably. The middle of an open field would perhaps prove a better spot.

From the foregoing facts you can readily see the immensity of the problems with which civilian defence authorities are faced. It is hoped that men and women of your extensive technical knowledge will give these problems serious consideration and give your local authorities the benefits of your thought. Whether anything I have said will bring this about or not, I wish to extend the thanks of the Boston Committee on Public Safety, as well as my personal thanks, to the officers of your organization for their kind invitation to appear before you and talk on a subject we believe to be vital to the safety of New England.

BOILING POINT AND VAPOR PRESSURE

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The effect of temperature on the vapor pressure and boiling point of a liquid may be vividly demonstrated by the following experiment. Fill a six inch test tube about two-thirds full of ether. Hold the tube and immerse as much of it as possible in a beaker of hot water. (Do not have a flame near the ether.) When the ether has boiled vigorously for a few seconds, close the test tube with a cork stopper and immediately remove it from the hot water. Cool the tube to room temperature with tap water. The ether may then be made to boil rapidly by holding the tube in an inverted position with the stopper in the hand. If the upper part of the tube is grasped firmly with the other hand, the boiling stops almost instantly. Remove the hand, and the boiling commences again. If the upper part of the tube is cooled, the boiling is more rapid.

After a few days the ether does not boil so rapidly as at first, and the stopper must be removed and the ether re-heated. If the stopper is covered with sealing wax and sealed to the tube the experiment can be repeated at any time over a period of several days. When the tube is used continuously, better results are obtained if the tube is cooled occasionally, with tap water.

It is the heat from the hand that increases the vapor pressure of the liquid ether until its vapor pressure exceeds the pressure of the ether vapor, thus causing boiling; but when the vapor pressure of the ether vapor is also increased by the heat from the other hand, the boiling stops.

(The boiling stops so quickly that I sometimes use the experiment as a mysterious action and say that the bubbles are squeezed back into the liquid.)

CLARIFYING ARITHMETIC THROUGH ALGEBRA

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For the great majority of students one of the most desirable outcomes of a course in algebra would be increased comprehension of the fundamental principles of arithmetic. Practically all students leaving the elementary schools are ignorant or unaware of the principles which continually recur and validate their mechanical manipulations. If insight into the operations and nature of arithmetic is to be attained and if fullest use of familiar arithmetic techniques as background material for the study of algebra is to be made, continual stress on underlying principles common to arithmetic and algebra is essential.

It is the purpose of this article to present situations in the algebra course of study where this mutual interplay between the two subjects is especially prominent.

One of the major obstacles in exhibiting algebra as a generalization of arithmetic is the loss of identity suffered by the original numbers in arithmetic operations, thereby concealing the essential similarity between them and their algebraic counterparts. It is important that this concept be clearly presented at the outset of a course in algebra and kept before the student throughout. Thereby, the student realizes readily that a binomial in algebra may be considered a monomial whose component parts have not been arithmetically merged and that every monomial may be converted into binomial and other forms.

BINOMIAL Component terms not merged	MONOMIAL Component terms merged
$a+b$	$a+b$ (merging postponed)
$4+3$	7
$9-2$	7
$4+\frac{1}{2}$	$4\frac{1}{2}$

Realization that a single quantity such as $4\frac{1}{2}$ may be thought of as the sum of two separate terms facilitates recognition of the similarity between algebraic situations of the form $a(b+c)$ and arithmetic situations of the form $2\times4\frac{1}{2}$. This parallel presentation of the distributive law of multiplication in both subjects serves as a reminder to pupils that each term of a mixed fraction

must be operated upon by the multiplier. While impressing upon students the necessity of recognizing situations subject to the distributive law, the teacher may wish to use analogous material in grammar frequently misinterpreted by casual readers. For instance, in the sentence "10 years ago, John's age was twice Harry's," the adjectival clause "10 years ago" must be "distributed over" the age of each boy.

MULTIPLICATION	DISTRIBUTION
$a\ (b+c)$	$a \cdot b+a \cdot c$
$2\times4\frac{1}{2}$	$2\times4+2\times\frac{1}{2}$
$2\ (4+3)$	$2\times4+2\times3$
2 couples	2 boys and 2 girls

Extension of the above symbolism to the form $(a+b)(c+d)$ is particularly significant, for here the pupil's arithmetic shows noticeable weakness. Students who are asked to multiply $2\frac{1}{2}\times2\frac{1}{2}$ tend to give 5 as an answer with a scattering of 6's and $6\frac{1}{2}$'s and and occasional correct response. Identifying this problem as the product of two binomials serves to focus attention on the operations indicated by the symbolism and assists considerably in elimination of error.

MULTIPLICATION	DISTRIBUTION	
$(a+b)(c+d)$	$(a+b)c+(a+b)d$	$ac+bc+ad+bd$
$(4+3)(5+2)$	$(4+3)5+(4+3)2$	$4\cdot5+3\cdot5+4\cdot2+3\cdot2$
$2\frac{1}{2}\times2\frac{1}{2}$	$2\frac{1}{2}\times2+2\frac{1}{2}\times\frac{1}{2}$	$2\cdot2+2\cdot\frac{1}{2}+2\cdot\frac{1}{2}+\frac{1}{2}\cdot\frac{1}{2}$

Vertical forms of multiplication should be employed as well as horizontal to emphasize clearly the operations used and their independence of any particular form. In the case of squaring a binomial, pupils should be made cognizant of the presence of each of the four steps of the process even though two of the resulting terms are combined because they are alike.

$$(a+b)^2 \qquad aa+ab+ba+bb \qquad a^2+2ab+b^2$$

Students will appreciate the concepts mentioned above much more when they see them applied in arithmetic computation to facilitate labor. For instance;

$17\times\ 9$	$17(10\ -1)$	$170-17$	153
13×99	$13(100-1)$	$1300-13$	1287

The principle of adding like terms merits special consideration. If like parts are considered common units and their coefficients are thought of as the number of units, similar terms are

added by totaling the *number* of *common units*. In this form, the principle has wide application in both algebra and arithmetic.

LIKE TERMS	COMMON UNIT	NO. IN EACH	TOTAL NO. UNITS
2 apples+3 apples	apple	2, 3	5 apples
2 \$5 bills+3 \$5 bills	\$5 bill	2, 3	5 \$5 bills
$\frac{2}{7}+\frac{3}{7}$	$\frac{1}{7}$	2, 3	5 sevenths
$2x+3x$	x	2, 3	$5x$

In the case of fractions, the unit fractional part should be presented concretely as a definite entity and the close relation between the word denominator and denomination (or kind), numerator and enumerate (or number) pointed out.

Another desirable outcome of a course in algebra, not often stressed, is release of the pupil's mind from the impression that the form of arithmetic computations is unique. For example, most pupils know only one form for multiplying 32 by 24; when new arrangements are employed, they are astounded and confused. Obviously, they have not learned to differentiate between elements of a process which are fundamental and those which have organizational value only. This can be corrected by presenting such problems as being analogous to binomial products of the type $(10a+b)(10c+d)$ where the separate products may be written in any arrangement, provided only that none is omitted. Pupils should be encouraged to devise variations of their own and to justify unfamiliar methods on the basis of familiar principles. Below are listed different arrangements of the same problem which are in use today or have been at some time.

32	32	32	32	32
23	23	23	23	23
96	64	6	736	~~96~~
64	96	9	Units 2×3	~~64~~
736	736	4	Tens $3\times3+2\times2$ (carry 1)	~~736~~
		6	Hundreds 3×3	
		736		

Particularly wide variation in the forms used is found in the addition of fractions. So firmly fixed are the particular methods learned that pupils find the transition to algebraic forms difficult. Literal representation affords a good opportunity to contrast essential operations and non-essential patterns, for the reason that numbers do not lose their identity in this form as

they do arithmetically. Novel short methods of adding fractions such as the one following will be appreciated all the more because they are understood.

ALGEBRAIC	ARITHMETIC
$\frac{a}{b}+\frac{c}{d}=\frac{ad+bc}{bd}$	$\frac{2}{3}+\frac{1}{2}=\frac{2\times2+1\times3}{3\times2}=\frac{7}{6}$

Analysis of this sort will enable capable students to devise short cuts of their own. Teachers who do not encourage students to analyze the methods used in short cuts, puzzles and tricks of magic are depriving them in part of awareness of the power of the algebraic methods and of the great satisfactions afforded by its knowledge. Material for this purpose can be found in any of the many books on mathematical amusements. One such illustration is the well known method for squaring a two digit number having the units digit 5. Here, the tens digit is multiplied by the next higher integer and 25 is suffixed.

$$(10a+5)^2 \qquad 100a^2+100a+25 \qquad 100a(a+1)+25$$

Other number amusements which lend themselves readily to algebraic clarification are those of the type "Pick a number, double it, add five, etc." Still another interesting device is used to determine the relative magnitude of two proper fractions. Here, the cross products indicated below reveal which fraction is larger.

$$\frac{a}{b}\gtreqless\frac{c}{d} \text{ according as } \frac{ad}{bd}\gtreqless\frac{cb}{db} \text{ according as } ad\gtreqless cb$$

$$\tfrac{2}{3}<\tfrac{5}{6} \text{ because } 2\times6<3\times5$$

Not only does application of algebraic methods to those of arithmetic reveal the underlying reasons for them but serves the additional valuable purpose of promoting clearer understanding of the nature of algebraic symbolism.

Too few of our high school graduates leave school with a clear comprehension of the nature of algebra and of the underlying principles of arithmetic. This points to the desirability of a course in the nature of an overview of arithmetic and algebra in the senior term, where arithmetic techniques can be reviewed with comprehension and where the greater maturity of the student coupled with increased understanding will result in increased interest and power in the use of mathematical techniques.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the ones submitted in the best form will be used.

LATE SOLUTIONS

1746, 1740. *Ruth T. White, Sheboygan, Wis.*
1729, 1732, 1736, 1740. *Felix John, Philadelphia, Pa.*
1733. *Bessie Lucas, Earlville, N. Y. Walter R. Warne, Rochester, N. Y.*
1723, 1729, 1730, 4, 5, 6, 9, 1740. *C. W. Trigg, Los Angeles, Calif.*
1738. *M. Kirk, West Chester, Pa.*

1741. *Proposed by Walter M. Sackett Jr., Evanston, Ill.*

Solve the system

$$x^2 = y$$
$$2^x = y$$

Solution by Paul D. Thomas, Durant, Okla.

By inspection two solutions are (2, 4), (4, 16).

To find the other consider the function

$$f(x) = x^2 - 2^x$$
$$f'(x) = 2x = 2^x \log_e 2. \ \mathrm{Log}_e 2 = .69315.$$

Use Newton's method of approximation.

$$x = a - f(a)/f'(a). \qquad (1)$$

When $x = -1$, $f(-1) = \frac{1}{2}$; for $x = 0$, $f(0) = -1$, hence let $a = -1$.

By (1)

$$x = -1 - f(-1)/f'(-1) = -1 + .213 = -.787.$$

Again by (1)

$$x = -.787 - f(-.787)/f'(-.787) = -.787 + .0202 = -.7668$$
$$y = x^2 = (-.7668)^2 = .5879.$$

The three solutions are (2, 4), (4, 16), (−.767, .588).

Solutions were also offered by M. H. Pearson, Montgomery, Ala.;

Norman Anning, Ann Arbor, Mich.; C. W. Trigg, Los Angeles, Calif.; W. R. Smith, Suttons Bay, Mich, and the proposer.

1742. *Proposed by Dr. Newton C. Jones, Niagara Falls, N. Y.*

"A tramp was making his weary way along the railroad tracks when he suddenly found himself in a terrible predicament. He was on a bridge just one track wide and a fast express train was approaching him at the rate of 90 miles per hour. At that instant the train was twice the length of the bridge away from the end of the bridge. The tramp made a lucky guess and ran toward the train just missing it a foot. If he had gone the other way he would have been hit three inches from the end of the bridge. How long was the bridge?"

Solution by Norman Anning, Ann Arbor, Mich.

Suppose the man is a feet from the "safe" end of the bridge, and b feet from the other end. Then;

the train goes $2a+2b-1$ feet while the man goes a feet and

the train goes $3a+3b-\frac{1}{4}$ feet while the man goes $b-\frac{1}{4}$ feet.

It follows from the sum of these that the train goes five times as fast as the man. As a consequence

$$2a+2b-1=5a \text{ or } 2b=3a+1.$$

This single equation is not sufficient for finding a and b. For instance, we might choose $a=1$, $b=2$, and have all conditions satisfied by a bridge one yard long.

However, the man cannot run on endlessly at 18 miles per hour. If n is the greatest number of feet which he can run at that killing rate, then the bridge can have any length up to within an inch or so of $(5n/3)$ feet.

It is, of course, assumed in the above discussion that the startled man instantly attains his maximum speed and that the engineer is merciless.

Solutions were also offered by Helen M. Scott, Baltimore, Md.; M. H. Pearson, Montgomery, Ala., and W. R. Smith, Suttons Bay, Mich.

1743. *Proposed by John P. Hoyt, Annapolis, Md.*

Find the volume of a tetrahedron whose edges are a, b, c, d, e, and f.

Solution by Paul D. Thomas, Durant, Okla.

Take one vertex of the tetrahedron at the origin, O, of coordinates. The other three vertices are $P(x_1, y_1, z_1)$, $Q(x_2, y_2, z_2)$ $R(x_3, y_3, z_3)$. $OP=a$, $OQ=b$, $OR=c$, $PQ=d$, $QR=e$, $RP=f$. Angle $POQ=D$, angle $QOR=E$, angle $POR=F$.

$$(1)\qquad 6V=\begin{vmatrix} x_1 & y_1 & z_1 \\ x_2 & y_2 & z_2 \\ x_3 & y_3 & z_3 \end{vmatrix}=\begin{vmatrix} x_1 & x_2 & x_3 \\ y_1 & y_2 & y_3 \\ z_1 & z_2 & z_3 \end{vmatrix}.$$ By multiplication,

$$36\cdot V^2=\begin{vmatrix} x_1 & y_1 & z_1 \\ x_2 & y_2 & z_2 \\ x_3 & y_3 & z_3 \end{vmatrix}\cdot\begin{vmatrix} x_1 & x_2 & x_3 \\ y_1 & y_2 & y_3 \\ z_1 & z_2 & z_3 \end{vmatrix}=$$

$$(2)\qquad \begin{vmatrix} x_1^2+y_1^2+z_1^2, & x_1x_2+y_1y_2+z_1z_2, & x_1x_3+y_1y_3+z_1z_3 \\ x_1x_2+y_1y_2+z_1z_2, & x_2^2+y_2^2+z_2^2, & x_2x_3+y_2y_3+z_2z_3 \\ x_1x_3+y_1y_3+z_1z_3, & x_2x_3+y_2y_3+z_2z_3, & x_3^2+y_3^2+z_3^2 \end{vmatrix}$$

$$=\begin{vmatrix} a^2 & ab\cdot\cos D & ac\cdot\cos F \\ ab\cdot\cos D & b^2 & bc\cdot\cos E \\ ac\cdot\cos F & bc\cdot\cos E & c^2 \end{vmatrix}$$

$$\cos D=(a^2+b^2-d^2)/2ab,\quad \cos E=(b^2+c^2-e^2)/2bc,\quad \cos F=(a^2+c^2-f^2)/2ac.$$

By substitutions in (2) and removal of factor 1/8 from right hand determinant.

$$288\cdot V^2=\begin{vmatrix} 2a^2 & a^2+b^2-d^2 & a^2+c^2-f^2 \\ a^2+b^2-d^2 & 2b^2 & b^2+c^2-e^2 \\ a^2+c^2-f^2 & b^2+c^2-e^2 & 2c^2 \end{vmatrix}. \tag{3}$$

Expanding this last determinant it is found that

$$144\cdot V^2=4a^2b^2c^2+(a^2+b^2-d^2)(b^2+c^2-e^2)(a^2+c^2-f^2)-a^2(b^2+c^2-e^2)^2$$
$$-b^2(a^2+c^2-f^2)^2-c^2(a^2+b^2-d^2)^2.$$

Solutions were also offered by Arthur Danzl, Collegeville, Minn.; Edna Kent, Auburn, N. Y.; Jamia Corwin, Mexico City, D. F.; W. R. Warne, Rochester, N. Y.

1744. *Proposed by Georgia Day, Romulus, N. Y.*

Find the area of the triangle ABC, in terms of the angles and s, where $2s$ is the perimeter.

Solution by Proposer

By use of the half angle formula, and Hero's formula

$$\tan\frac{A}{2}\tan\frac{B}{2}\tan\frac{C}{2}=\frac{1}{s}\sqrt{\frac{(s-a)(s-b)(s-c)}{s}}$$
$$=\frac{1}{s^2}\sqrt{s(s-a)(s-b)(s-c)}$$
$$=\frac{\text{Area}}{s^2}.$$

Hence

$$\text{Area}=s^2\tan\frac{A}{2}\tan\frac{B}{2}\tan\frac{C}{2}.$$

Solutions were also offered by M. H. Pearson, Montgomery, Ala.; Vern Newman, Bearytown, N. Y.; Norman Anning, Ann Arbor, Mich.; Sophia Day, Romulus, N. Y.; Arthur Danzl, Collegeville, Minn.; Cecil B. Read, Wichita, Kan.; Ruth Taylor White, Sheboygan, Wis.; Aaron Buchman, Buffalo, N. Y.; C. W. Trigg, Los Angeles, Calif.

1745. *Proposed by Ethel Kunes, Starkey, N. Y.*

In triangle ABC, show that

$$\sin(B-C)=\frac{b^2-c^2}{a^2}\sin A.$$

Solution by Malcolm Kirk, West Chester, Pa.

By use of laws of sines and cosines

$$\sin(B-C)=\sin B\cos C-\sin C\cos B=\frac{\sin A}{a}(b\cos C-c\cos B)$$
$$=\frac{\sin A}{a}\left[\frac{b(a^2+b^2-c^2)}{2ab}-\frac{c(a^2+c^2-b^2)}{2ac}\right]$$
$$=\frac{b^2-c^2}{a^2}\cdot\sin A.$$

Solutions were also offered by Arthur Danzl, Collegeville, Minn.; Ruth Taylor White, Sheboygan, Wis.; Brother Felix John, Philadelphia, Pa.; Nell Adair, Stanley, N. Y.; C. W. Trigg, Los Angeles, Calif.; Lester Bolander, Baltimore, Md.; Seeley Warne, Tecumseh, Mich.; Walter R. Warne, Rochester, N. Y.; Edith M. Warne, Rochester, N. Y.; Paul D. Thomas, Durant, Okla.; Isaac Adair, Kendaia, N. Y.; M. H. Pearson, Montgomery, Ala.; Norman Anning, Ann Arbor, Mich.; and the proposer.

1746. *Proposed by Walter R. Warne, Rochester, N. Y.*

In triangle ABC find the length of AH, H being the ortho-center, in terms of angle A and side a.

Solution by Aaron Buchman, Buffalo, N. Y.

Let O be the center of the circumcircle, let D be the midpoint of BC, and let E be the midpoint of AC.

Then it is easily shown that triangle BHA is similar to triangle EOD.

Since $DE=\frac{1}{2}AB$, then $OD=\frac{1}{2}AH$.

But by drawing the circumcircle, it is easily shown that $OD=\frac{1}{2}a \cot A$.

Then, $AH=a \cot A$.

Solutions were also offered by Paul D. Thomas, Durant, Okla.; Norman Anning, Ann Arbor, Mich.; Walter R. Warne, Rochester, N. Y.; Matie Smith, Romulus, N. Y.; Theodore Marsh, Richmond, Va.; Charles S. Warne, Tecumseh, Mich.; Malcolm Kirk, West Chester, Pa., and M. H. Pearson, Montgomery, N. Y.

STUDENT HONOR ROLL

This editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted to this department. Teachers are urged to report to the Editor such solutions.

No solutions were offered for this issue.

PROBLEMS FOR SOLUTION

1759. *Proposed by John P. Hoyt, Annapolis, Md.*

If quadrilateral $ABCD$ be inscribed in a circle with AB and DC meeting at E; AD and BC meeting at F; with EH and FG as tangents, prove that $\overline{EF}^2=\overline{EH}^2+\overline{FG}^2$.

1760. *Proposed by Claude P. Rook, Chillicothe, Ohio.*

The curves $y=x \log x$ and $y=x \log (1-x)$ intersect at the origin and at another point A. Find the angle of intersection at A.

1761. *Proposed by D. F. Wallace, ———*

If x, y, z, are integers such that

$$x-y=-1$$
$$x^2+y^2=z^2$$

Show that $2x+y+2z$ and $x+2y+2z$ are consecutive integers, the sum of whose squares is the square of an integer.

1762. *Proposed by Walter M. Sackett, Evanston, Ill.*

By use of trigonometry solve $80x^5-100x^3+25x-1=0$.

1763. *Proposed by Paul C. Overstreet, Wilmore, Ky.*

On March 11, 1939 I had been married half my life. On November 9, 1941 I shall be twice as old as my son who was born in 1916. I was married on the 8th day of June. Give the exact date of my birth.

1764. *Proposed by Julius Brandstatter, Los Angeles, Calif.*

Show that

$$\sin x < x \text{ and } \sin x > x - \frac{x^2}{2}.$$

SCIENCE QUESTIONS

March, 1942

Conducted by Franklin T. Jones,
10109 Wilbur Avenue, SE, Cleveland, Ohio

Contributions are desired from teachers, pupils, classes and general readers. Send examination papers from any source whatsoever, questions on any part of the field of science, tests, questions having to do with the pedagogy of science—in fact, anything that appeals to the reader or might appeal to other readers; also, anything that will help to make the subjects arrayed under SCIENCE more useful or more interesting to teachers and pupils. Select your own topic. It will, most likely be interesting to others.

We will endeavor to get answers to all reasonable questions. It is always valuable to get questions whether they can be answered or not.

Contributors to SCIENCE QUESTIONS are accepted into the GQRA (Guild of Questions Raisers and Answers).

Classes and teachers are invited to join with others in this co-operative venture in science.

HOW TO KEEP UP WITH SCIENCE AND INDUSTRY?

Is our monthly question for 1942.

REQUESTS BY READERS

(Under this heading will be carried the names of those who wish to be put in the way of "Keeping Up With Industry.")

950. *Requests on "How to Keep Up With Science and Industry in 1942."*

(1)—By Joseph W. Brewer, Science Instructor, Eskridge Rural High School, Eskridge, Kansas.

"Please send list of industrial concerns who will place our Science Department on their mailing list for educational material."

(2)—By Fannie Hopkins, 114 West Avenue, N., Waukesha, Wis.

"I noted your courteous offer in SCHOOL SCIENCE AND MATHEMATICS, and would appreciate if you would forward my name to be put on the courtesy mailing list of the Customer Research Staff of General Motors Corporation."

(3)—By Science Instructor Kassay, High School, Newton, Pa.

"In the January issue of SCHOOL SCIENCE AND MATHEMATICS I was much impressed by the article about fire bombs.

Can you give me the necessary information where I can get detailed information on fire and explosive bombs?

I'm anxious to organize a course of study to give instruction in the work.

Are there any text-books written on the subject?

Does the Government give information?

Partial Answers to 950 (just above)

The *Editor* of this Department of SCIENCE QUESTIONS is on the mailing list of a large number of publications, some "pay subscription," some free, some governmental, some educational, some industrial, many chemical and scientific. He cannot guarantee that all would be willing to send copies to a large number.

Answer from Henry G. Weaver (GQRA, No. 343), Director, Customer Research Staff, General Motors Corporation, 3044 West Grand Boulevard, Detroit, Mich.

In effect, Mr. Weaver will be glad to supply publications of his Customer Research Staff as long as the supply as available.

The *Editor* will send in the three names above to Mr. Weaver together with other names that may be sent in later. (I find these publications of great interest and value. They are strictly up to date. Many quotations from them have been made in this Department. Please note that *Question 910.* WHAT MAKES AN AUTOBOMILE GO? was derived from this source as well as the answer. Question published in January, 1941; Answered in January 1942, from the same source; No answers from readers of SCHOOL SCIENCE AND MATHEMATICS! FTJ.)

Answer from John G. Mapes of the "American Iron and Steel Institute," 350 Fifth Avenue, New York, N. Y., publishers of "Steel Facts."

"Thank you for sending me the reprint of SCIENCE QUESTIONS, in which you showed the use of our "Steel Quiz" (SCIENCE QUESTIONS, No. 920, October, 1941; and No. 949, February, 1942). I am glad to know that you found this quiz interesting, and I hope you will use it as often as it suits your convenience.

While my acquaintance with the publications of other industries is not very broad, I would suggest that you attempt to get on the mailing list of "Automobile Facts" published by the Automobile Manufacturers Association, Detroit, Mich.; and also the publication, "Machine Tools," published by the National Machine Tool Builders Association, Cleveland, Ohio."

Other Trade Publications from which no specific letters have been received.

1. Reprints of advertisements of REPUBLIC STEEL CORPORATION, C. M. White, Vice President in Charge of Operations, Cleveland, Ohio. (Each issue has a colored print that is well worth framing. FTJ.)
2. "QUIZ" ON RAILROADS AND RAILROADING (400 Questions and Answers). Association of American Railroads, Washington, D. C. (Free.)
3. Public Relations Dept. publications of Association of Eastern Railroads, New York, N. Y.
4. "The Educational Focus," Bausch & Lomb Optical Company, Rochester, N. Y. (Possibly available on request.)
5. "Research Progress," Westinghouse Research Laboratories, East Pittsburgh, Pa. (Possibly available on request.)
6. Free Booklet—"Here's the Way to Keep Your Tires Safe to their Last

Gasp" (Ad in Collier's, for January 17, 1942). Goodyear, Dept. P1, Akron, Ohio.

7. The Macmillan Co's. Book List, monthly (probably free on request).
8. "CHEMISTRY IN ACTION," Truesdail Laboratories, Inc., Chemists and Bacteriologists, 520 West Avenue 26, Los Angeles, Calif. (Possibly a sample copy on application.)
9. Book advertisements of Wm. H. Wise & Co., Inc., 50 West 47th St., New York, N. Y.

For Sale at Regular Subscription Prices.

1. "SCIENCE NEWS LETTER" (weekly), Science Service, 2101 Constitution Avenue, Washington, D. C.
   (Trial Subscription—about four months for $1.00; to members of American Assn. of Physics Teachers, $3.00 a year; quite likely Central Assn. of Science and Mathematics Teachers might get the same rate on request to Watson Davis, Director.)
2. "Consumers' Guide," published by Consumers' Counsel Division, U. S. Department of Agriculture, Washington, D. C.—$1.00 a year; BUT your Congressman might get it for you for nothing! Try it anyway.

Articles in THE WEEKLY MAGAZINE that accompanies your Sunday paper.

NEWS ITEMS in the daily papers.

ARTICLES in publications like the READER'S DIGEST, SATURDAY EVENING POST, COLLIER'S, LIFE, and a lot more.

Several most valuable Employees' and Stockholders' Publications that can be mentioned only if the Editor should happen to know what "pull" you have and what stocks you own. Usually opportunities come to get on Stockholders' Lists when the Company mails you a dividend check.

TEXT BOOKS and Government publication are likely to be somewhat slower in making up-to-date information available than articles in publications by the Company that has the product for sale.

Answer to Science Instructor Kassay, Newtown, Pa. concerning FIRE BOMBS.

The best popular account of FIRE BOMBS and HOW TO EXTINGUISH THEM is to be found in the EMPLOYERS PIONEER for September, 1941, and November, 1941. Possibly you can get your insurance agent to get a copy for you. The November number contains a series of *eight* illustrations showing how to extinguish a fire bomb that could be enlarged by your Mechanical Drawing Dept. (Use a pantagraph), or by some artistic student, or by your Art Dept. and then posted on your Bulletin Boards as part of your Fire Protection (or Air Raid) Drills. *Remember:* If you know how to fight an ordinary fire, and have a little additional information about burning magnesium and *thermite*, you can do pretty well in handling explosive and fire bombs. After the war is over, it won't do your pupils any harm to know how to fight a grass fire, a forest fire, a fire in a partition, or a gasoline fire and it surely will save property if not a life.

(The September, 1941, article referred to above is also printed in Best's INSURANCE NEWS, I think, for October, 1941.)

A MATHEMATICAL QUESTION WITH A MECHANICAL ANSWER

951. *Proposed by Robert Torkelson (Elected to the GQRA, No. 419), Central State Teachers' College, Stevens Point, Wisconsin.*

"Is it at all possible to trisect *any* angle?"

"This problem has been in my mind since my sophomore year in high school. I am now a mathematics and science major here at Central State Teachers College."—"I have been very much interested in problems and solutions brought out in your magazine."

Hints toward a solution:

Read under "trisection" in Century Dictionary.

Read under "trisectrix" in *Encyclopedia Britannica.*

Read "LICKS: RECREATIONS IN MATHEMATICS."

Since solutions are mechanical rather than Euclidean, the question is regarded as a proper one for this Department.

SOLUTIONS FROM THE MECHANICAL POINT OF VIEW ARE PARTICULARLY REQUESTED.

Why can the problem not be solved with a straight edge and compasses as permitted by Euclidean Plane Geometry?

THE COW WORKS

952. *From "Brain Teasers," edited by F. Benington, in THE DOUBLE BOND of the Western New York Section of The American Chemical Society.*

"Find how much work was done when the cow jumped over the moon."

(This cow weighs 900 pounds in pasture; but, as she went up, her weight varied inversely as the square of her distance from the center of the earth, and this distance varied from 4,000 miles in the pasture to 240,000 miles at the moon.)

BLOWING UP OUR ENEMIES WITH VOLCANOES

953. *Dr. Harold O. Whitnall, Professor of Geology, Colgate University, tells how to "touch off" volcanoes by aerial bombs, in "The American Weekly" (Sunday Supplement) for January 25, 1942.*

How might a volcano in enemy territory be started into eruption?

Answer—The author of this article describes, with excellent illustrations, an eruption of Oshima, one of Japan's worst "Dragons of the Earth" which caused the great earthquake of 1923. (It is excellent Bulletin Board material.)

Also, he suggests how a "one-ton" bomb might serve "as the emetic" which might hasten the slower processes of nature.

Here is an opportunity for classes to do a little studying on the possible ways in which volcanoes work with their accompanying lava eruptions and earthquakes. Let the boys draw their own diagrams and show how possible infiltration of water may touch off a volcanic eruption and also how a bomb dropped into the crater of the volcano might help the operation along.

Do a little imaginative tinkering with Dame Nature's plumbing!

THE RUSSIAN-JAP WAR

954. *DID YOU KNOW that in the Russian-Japanese War (Was it in*

1904–5?) the Japs avoided typhoid by forcing the drinking of tea instead of water?

It was then reported that a regular ration and piece of equipment for each Jap soldier was an alcohol lamp and a ration of tea. Simple as could be, the Japs boiled their water to make the tea and so avoided any effects from contaminated water.

THE RESULTS OF WARS—DISEASE

955. *Article by John W. W. Sullivan, Sc.D. in Cleveland Plain Dealer, Jan. 23, 1942.*

(For the attention of Biologists and Social Scientists.)

Will "post-war" diseases come again?

Typhus fever and its group of diseases "spread vigorously through Central Europe wherever famine and unsanitary living conditions prevailed. Two more years of World War II may result in a post-war epidemic greater than the last."

"Typhus fever is a family of closely related diseases borne by infected parasites such as lice and fleas which infest rats and other rodents. The majority of the typhus viruses are believed to be parasites which inhabit the intestinal walls of their hosts and are too small for detection by the ordinary microscope. One of the typhus family is reported to resemble small bacteria. The nature of the viruses may soon be discovered by the electron microscope. This powerful instrument has revealed the rod-shaped virus of small-pox and the pulsating globs of bacteria that produce boils."

"Also known as jail fever, famine fever, putrid fever, and spotted fever, this family of contagious diseases produces an eruption of red spots on the body along with a high fever and severe prostration during a period of two or three weeks. These diseases seem to smolder in rats but flare up with deadly effect when they strike man, particularly when body resistance is reduced by starvation and despair."

"During World War I, typhus was kept at bay on the eastern front by extensive bathing and de-lousing of German and Austrian soldiers."

Mortality is very high.

References: "Rats, Lice and History," by Hans Zinsser;
"Biological Aspects of Infectious Diseases," by F. M. Burnet.
Article: "Typhus Fever," Encycl. Brit.

SEND IN REFERENCES TO ARTICLES THAT PRESENT-DAY PROBLEMS DICTATE SHOULD BE READ BY TEACHERS AND PUPILS

JOIN THE GQRA!

BOOKS AND PAMPHLETS RECEIVED

MATTER, ENERGY AND RADIATION, by J. R. Dunning, *Associate Professor of Physics, Columbia University*, and H. C. Paxton, *Instructor in Physics, Columbia University*. First Edition. Cloth. Pages xvi+668. 15 ×22.5 cm. 1941. McGraw-Hill Book Company, 330 W. 42nd Street, New York, N. Y. Price $3.50.

MATHEMATICS FOR THE AVIATION TRADES, by James Naidich, *Chairman, Department of Mathematics, Manhattan High School of Aviation Trades.* Cloth. Pages x+267. 15×23 cm. 1942. McGraw-Hill Book Company, 330 W. 42nd Street, New York, N. Y. Price $1.80.

ENRICHED TEACHING OF SCIENCE IN THE HIGH SCHOOL, by Maxie Nave Woodring, *Associate Professor of Education, Teachers College, Columbia University;* Mervin E. Oakes, *Instructor in Biology, Queens College of the City of New York;* and H. Emmett Brown, *Teacher of Science, Lincoln School. Teachers College, Columbia University.* Cloth. Pages xii+402. 14.5 ×23 cm. 1941. Bureau of Publications, Teachers College, Columbia University, New York, N. Y. Price $3.25.

EXPERIMENTAL PHYSICAL CHEMISTRY, by W. G. Palmer, *Fellow of St. John's College, Cambridge University Lecturer in Chemistry in the University of Cambridge,* Cloth. Pages xi+321. 13×21 cm. 1941. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $2.75.

UNIVERSITY PHYSICS, PART FOUR, WAVE-MOTION AND SOUND, by F. C. Champion, *Lecturer in Physics, University of London.* Cloth. 67 pages. 14×22 cm. 1941. Interscience Publishers, Inc., 215 Fourth Avenue, New York, N. Y. Price $1.65.

THE PHILOSOPHY OF ALFRED NORTH WHITEHEAD, Edited by Paul Arthur Schilpp, *Northwestern University.* Cloth. Pages xviii+745. 14.5 ×23 cm. 1941. 302 Harris Hall, Northwestern University, Evanston, Ill. Price $4.00.

ALGEBRAIC SOLID GEOMETRY, by S. L. Green, *Senior Lecturer in Applied Mathematics, Queen Mary College, University of London.* Cloth. 133 pages. 11.5×18.5 cm. 1941. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $1.75.

A FIRST COURSE IN TRIGONOMETRY, by W. J. Oliver, *Central Collegiate Institute, Regina, Saskatchewan;* P. F. Winters, *Scott Collegiate Institute, Regina, Saskatchewan;* and J. E. Campbell, *Central Collegiate Institute, Regina, Saskatchewan.* Cloth. 269 pages. 12.5×18.5 cm. 1941. School Aids and Text Book Publishing Company, Ltd., Regina and Toronto. Price $1.25.

THE FOUNDATIONS OF CONSERVATION EDUCATION, Prepared under the auspices of the Committee on Conservation Education, Henry B. Ward, *Chairman and Editor, University of Illinois, Urbana, Ill.* Cloth. Pages vi+242. 12×18.5 cm. 1941. The National Wildlife Federation, 1212 Sixteenth Street, N.W., Washington, D. C.

PHYSICAL SCIENCE, by Charles H. Nettels, Paul F. Devine, Walter F. Nourse, and M. E. Herriott of *Los Angeles City Schools.* Cloth. Pages xxiv +464. 15+23.5 cm. 1942. D. C. Heath and Company, 285 Columbus Avenue, Boston, Mass. Price $2.24.

CLOUDS, AIR AND WIND, by Eric Sloane, Cloth. 76 pages. 22.5×30.5 cm. 1941. The Devin-Adair Company, 23 East 26th Street, New York, N. Y. Price $2.50.

HANDBOOK OF CHEMISTRY AND PHYSICS. Twenty-fifth Edition. Editor in Chief, Charles D. Hodgman, *Associate Professor of Physics in Case School of Applied Science; Associate Editor,* Harry N. Holmes, *Professor of Chemistry at Oberlin College.* Cloth. Pages xviii+2503. 11.5×18 cm. 1941.

Chemical Rubber Publishing Company, 1900 West 112th Street, Cleveland, Ohio. Price $3.50 in United States, and $4.00 Elsewhere.

IT WORKS LIKE THIS, by Captain Burr Leyson. Cloth. 224 pages. 13×20.5 cm. 1942. E. P. Dutton and Company, Inc., 300 Fourth Avenue, New York, N. Y. Price $2.50.

FIRST YEAR COLLEGE MATHEMATICS, by Cleon C. Richtmeyer, Ph.D., and Judson W. Foust, Ph.D., *Central Michigan College of Education, Mt. Pleasant, Michigan.* Cloth. Pages xi+461. 15×23 cm. 1942. F. S. Crofts and Company, 101 Fifth Avenue, New York, N. Y. Price $3.25.

WHAT IS TRUTH, by Glen Hilding Draper, *Trustee, Research Institute, Washington, D. C., Associate-Astronomer, Mathematician of the United States Naval Observatory.* Cloth. 122 pages. 13.5×20.5 cm. 1941. Ransdell Inc., 810–16 Rhode Island Avenue, N.E., Washington, D. C.

THE HIGH-SCHOOL SCIENCE LIBRARY FOR 1940–1941, by Hanor A. Webb, *Editor of Current Science, George Peabody College for Teachers, Nashville, Tennessee.* Paper. 15 pages. 16×24 cm. Reprinted from the Peabody Journal of Education, Volume 19, No. 3, November, 1941.

MONTHLY WEATHER REVIEW, Supplement No. 45, by Richard Hanson Weightman, *Weather Bureau, Washington, D. C.* Paper. Pages viii+99. 23.5×30.5 cm. 1941. Superintendent of Documents, Washington, D. C. Price 30 cents.

SUPERVISION OF SECONDARY EDUCATION AS A FUNCTION OF STATE DEPARTMENTS OF EDUCATION, by Carl A. Jessen, *Senior Specialist in Secondary Education* and W. T. Spanton, *Chief, Agricultural Education Service.* Bulletin 1940, No. 6. Monograph No. 9. Pages vi+44. 15×23 cm. Superintendent of Documents, Washington, D. C. Price 10 cents.

SIXTH ANNUAL REPORT OF HUNTINGTON COLLEGE BOTANICAL GARDEN AND ARBORETUM, by Fred A. Loew, *Director,* 14 pages. 14×21.5 cm. December, 1941. Huntington College, Huntington, Ind.

REPORT OF THE PRESIDENT OF COLUMBIA UNIVERSITY FOR 1941. 66 pages. 15×23 cm. Columbia University, New York, N. Y.

CURRICULUM BULLETIN, NO. 13, UNIVERSITY OF OREGON: Suggestions for a Junior High School Curriculum, A Study Guide for Teachers and Administrators, prepared by Hugh B. Wood, *Professor of Education, University of Oregon.* 9 pages. 21.5×28 cm. March 1. 1940. University Cooperative Store, Eugene, Oregon. Price 15 cents.

CURRICULUM BULLETIN, NO. 33, UNIVERSITY OF OREGON: Insurance, A High School Social and Economic Mathematics Unit, prepared by Betty McGirr, *Mathematics Teacher,* Vale, Oregon. 14 pages. 21.5×28 cm. April 15, 1941. Price 20 cents.

CURRICULUM BULLETIN, NO. 38, UNIVERSITY OF OREGON: Curriculum Trends and Recommendations for a 12-Year Science Program, prepared by a Committee of The Oregon System of Higher Education Curriculum Class, Portland, Spring, 1941. Hugh B. Wood, *Instructor, University of Oregon.* 23 pages. 21.5×28 cm. May 15, 1941. University Cooperative Store, Eugene, Oregon. Price 30 cents.

CURRICULUM BULLETIN, NO. 39, UNIVERSITY OF OREGON: Curriculum Trends and Recommendations for a 12-Year Mathematics Program, pre-

pared by a Committee of The Oregon System of Higher Education Curriculum Class, Portland, Spring, 1941. Hugh B. Wood, *Instructor*. 29 pages. 21.5×28 cm. May 20, 1941. University Cooperative Store, Eugene, Oregon. Price 30 cents.

CURRICULUM BULLETIN, No. 42, UNIVERSITY OF OREGON. A Framework for American Educational Philosophy, prepared by Oregon System of Higher Education Curriculum Classes under the Direction of Hugh B. Wood, *Professor of Education*, 15 pages. 21.5×28 cm. June 5, 1941. University Cooperative Store, Eugene, Oregon. Price 25 cents.

CURRICULUM BULLETIN, No. 43, UNIVERSITY OF OREGON: Improving Pupil Evaluation and Marking, A Handbook for a Study Conference held at Chattanooga, Tennessee, February 27–March 1, 1941, prepared by Hugh B. Wood, *Professor of Education, University of Oregon*. 15 pages. 21.5×28 cm. June 10, 1941. University Cooperative Store, Eugene, Oregon. Price 25 cents.

THE SCHOOL CURRICULUM AND COMMUNITY LIFE, by Hugh B. Wood, *Professor of Education, University of Oregon*. Reprint from *Commonwealth Review*, Vol. 21, No. 5, 1940. 21 pages. 15×23 cm. University of Oregon, Eugene, Oregon. Price 25 cents.

THE OHIO TEACHING RECORD. 29 pages. 18.5×25.5 cm. 1941. College of Education, Ohio State University, Columbus, Ohio. Price 25 cents; orders of 100 or more, 15 cents each.

THE REVISED OHIO TEACHING RECORD, by Louis Raths, *College of Education, Ohio State University, Columbus, Ohio*. Reprinted from *Educational Research Bulletin*, Vol. XX, No. 9, 1941. 15×23 cm.

BOOK REVIEWS

A SURVEY OF MODERN ALGEBRA, by Garret Birkhoff and Saunders Maclane, *Associate Professors of Mathematics in Harvard University*. Cloth. Pages xi+450. 14.5×21.5 cm. The Macmillan Company, New York, N. Y. 1941. Price $3.75.

The book is written as an elementary text, that is, for advanced undergraduates or first year graduate students. A year course could be selected which would require, technically, only high school algebra; probably only the superior student would succeed with this minimum of preparation. An outstanding feature of the book would seem to be the illustration of new terms and concepts by familiar examples; one might quote as an illustration the introduction to congruences by pointing out that in giving the time of day we count to 12 and then begin over again.

An extremely valuable feature is the unusually large number of exercises, coupled with the fact that the more difficult exercises have been indicated. From the teacher's viewpoint, it is worthwhile indicating that not only are many of the chapters independent units, but that many sections have been starred, indicating that they may be omitted without destroying continuity.

Whether or not one could use this book as a text, it should be considered as valuable reference material. Some idea of the material included may be given by listing selected chapter titles: The Integers; Rational Numbers and Fields; Complex Numbers; Group Theory; Vectors and Vector Spaces;

The Algebra of Matrices; Linear Groups; Algebra of Classes; Transfinite Arithmetic; Rings and Ideals; Galois Theory.

The index is very complete, in addition there is a special index of symbols used.

CECIL B. READ
University of Wichita

THE PRINCIPLES OF FINANCIAL AND STATISTICAL MATHEMATICS, by Maximilian Philip, Sc.D., C.P.A., *Professor of Mathematics in the School of Business and Civic Administration of the College of the City of New York.* Revised Edition. Cloth. Pages xvi+335, tables to accompany, paper, 28 pages, in pocket on back cover. 14×21 cm. Prentice-Hall, Inc., New York, N. Y. Price $3.50.

The material covered is not usually found in a single volume. Part I includes material in arithmetic, elementary algebra and simple geometric relations. It should provide good reference and review material, and might be used a regular class work for students with little high school work in mathematics. Part II includes much of the material offered in standard works on financial mathematics. The binomial theorem and the method of finite differences are presented, but very briefly, especially in the case of the binomial theorem. Part III is entitled "Statistical Methods." It would probably be classified as primarily mathematical statistics rather than applied statistics. The material of this part is very noticeably more difficult than that of the first part. Answers are provided to the major portion of the exercises. In several places the number of problems seems hardly adequate, particularly if it is desired to make different problem assignments in different semesters.

In some places one might question certain statements, for example on page 97 it is implied that c^x has a meaning for all values of x, yet if $x=\frac{4}{12}$ one may encounter trouble. According to the definition on page 100 the common logarithm of 1000 has no mantissa. On the other hand certain sections are definitely to be commended; for example the material on abbreviated multiplication and division. The chapter on approximate calculations might have appeared earlier, but seems to be a unit in itself, and could be taught earlier if desired.

CECIL B. READ

WHAT IS MATHEMATICS, an Elementary Approach to Ideas and Methods, by Richard Courant, *Head of the Department of Mathematics, New York University* and Herbert Robbins, *Instructor in Mathematics, New York University.* Cloth. Pages xix+521. 15×23 cm. 1941. Oxford University Press, London and New York.

This book has been written for a text or reference book for the many college courses which aim to present a picture of mathematics as a whole rather than stressing some particular field. While the only prerequisite would be a good high school foundation in mathematics, the book by no means attempts to make a sugar coated pill out of mathematics. An attempt is made to proceed from the simplest elements toward a grasp of the problems of advanced mathematics. A considerable body of material is so indicated that it can be omitted without destroying continuity; in fact much of this would necessarily have to be omitted by those with weak previous preparation.

The teacher accustomed to the traditional text will find that the supply of problems, particularly numerical examples, is very small. It would prob-

ably be necessary to supplement the book in many cases unless the course is a wide departure from past custom.

Very definitely this book should be in the library of every high school and college and also in the library of every mathematics teacher. It is not a collection of recreations, puzzles, or oddities—rather it is a serious book that will require intensive study in spots. Here one can find an answer to the question often asked, "What is Mathematics?"

CECIL B. READ

ELEMENTARY LABORATORY EXPERIMENTS IN ORGANIC CHEMISTRY, by Roger Adams, *Professor of Organic Chemistry, University of Illinois*, and J. R. Johnson, *Professor of Organic Chemistry, Cornell University*. Cloth. Pages xvi+420. 24 figs. 14×21 cm. 1940. The Macmillan Co., Inc., 60 Fifth Ave., New York, N. Y. Price $2.00.

The third edition of this well known laboratory manual combines all the advantages which the authors introduced into their previous editions with improvements derived from further experience and from the introduction of a number of new experiments which incorporate factors developed in the recent progress of synthetic organic chemistry.

The exercises are designed for use by any group of beginning students in organic chemistry. Different sequences of experiments may be selected depending upon the needs of the students. The book may be made the basis for a one or two semester course. The new experiments are chosen as before with the idea of using relatively inexpensive and readily available material. They illustrate 1) the formation of polymers and depolymerization so that the student may work with a type of modern resin, 2) a new synthesis of aspirin and sulfanilamide, new medicinals, 3) cyclohexene and cyclohexane, alicyclic compounds, 4) a reaction involving a new oxidation catalyst, vanadium oxide.

The introductory sections which discuss the basic laboratory operations and techniques have been improved and expanded. Theoretical and practical points have been further emphasized in connection with a number of the preparations. More test reactions have been added to broaden the field which can be covered. This is not done at the expense of the stress on the importance of preparation of products with good yield in some quantity. A new figure shows a good type of air driven stirrer. With this additional material, the new edition has been expanded fifty-seven pages with four more figures.

The book features an excellent discussion of the treatment of accidents in the laboratory; suggestions from the organic literature for supplementary experiments; charts for the time allowance, materials and reagents required for each experiment; tables of physical constants for a few organic compounds and needed density and vapor pressure data. The pages, printed on one side, are perforated for removal if desired. This text has been tested by large classes and is found to be a reliable and instructive aid in teaching fundamental organic laboratory procedure.

VIRGINIA BARTOW
University of Illinois

MATHEMATICS FOR ELECTRICIANS, by Martin H. Kuehn, *Instructor of Mathematics, Seneca Vocational High School, Buffalo, New York*. Second Edition. Cloth. Pages xi+254. 13.5×20.5 cm. 1941. McGraw-Hill Book Company, 330 West 42nd Street, New York, N. Y. Price $1.75.

The text is a revision of an earlier edition in which the author states that he has added several chapters on alternating-current problems, completely rewritten several chapters, and made minor changes in others. The purpose of the book is to combine in one volume instruction and practice exercises in both solving problems in practical electricity and principles of mathematics required in their solution. Topics in electricity include Ohm's Law, solution of series circuits, resistances in parallel, power in the electrical circuit, capacity of conductors, parallel circuits, generator and motor problems, battery problems, Kirchhoff's Laws and alternating current. The mathematical content of the text includes all of the content of the traditional course in elementary algebra plus similar figures, trigonometric functions, the slide rule, vectors, and complex quantities.

The explanations that accompany each new topic are simple, direct, and concise. There is an abundance of carefully selected exercise material on all topics, and illustrations are good. In addition to its usefulness as a textbook for classroom use the book will interest the electrician or mechanic who wants to study the mathematics of his trade and the teacher of mathematics who wants to be informed on practical applications of his subject even though their direct use in his classroom may be limited.

G. E. HAWKINS
LaGrange, Illinois

BUSINESS ARITHMETIC, A REVISION OF THE ORIGINAL THOMPSON'S BUSINESS ARITHMETIC, by Henry Smithline, *Instructor in Business Mathematics, New Utrecht High School and School of Commerce, St. John's University, New York City*, and Clyde O. Thompson, *Late Associate Principal, Mount Vernon, New York High School and Supervisor of Commercial Education, Mount Vernon, New York.* Cloth. Pages xi+496. 15×23 cm. 1941. Prentice-Hall, Inc., 70 Fifth Avenue, New York, N. Y. Price $1.60. This book is a complete revision of a 1929 edition by the same authors.

While it is intended for use in classes in commercial arithmetic, it attempts to develop an appreciation of the significance of arithmetic in dealing with social and economic situations. The authors state that the main features of the book are: (1) Unit-lesson organization and ample supply of problems; (2) Daily drills in fundamental operations; (3) Mental arithmetic drill for every lesson; and (4) Practical teaching procedures.

The text contains sufficient material for a full year course. Problems from the various fields of business have been included. Practical suggestions for attacking problems and six steps to follow in solving problems are presented. The problems in each lesson are classified under three headings —fundamental problems, mental problems, and written problems.

In the section on Problems in Manufacturing, the authors have treated particularly well the topics on Depreciation and Payrolls. Home-ownership in Unit Six is quite comprehensive and includes financing the house, the maintenance of real estate, fire insurance, collecting on insurance, and making alterations. The units on Money and Credit and Social Security could be treated more extensively.

The text is suitable for the use of junior and seniors in high schools. Teachers interested in a text in this subject will want to examine it.

A. W. YOUNGBLOOD
LaGrange, Illinois

ALEXANDER LIBRARY EXPERIENCES, by Carter Alexander, *Library Professor, Teachers College, Columbia University.* For use with the Second

Edition of *How to Locate Information and Data.* Paper. 158 pages. 21×28 cm. 1941. Bureau of Publications, Teachers College, Columbia University, New York, N. Y. Price $1.50.

For graduate or undergraduate students in education this work book should prove almost indispensable. Designed to accompany the text *How to Locate Educational Information and Data*, now in its second edition and highly recommended by educators and librarians, the workbook covers quite completely all the reference and bibliographic problems likely to face the research student. Aside from the purely technical processes such as making a bibliography, note-taking, and using the card catalog, there are discussions of such important topics as maps and charts, audio-visual aids, new items, professional literature and government documents. To facilitate the use of the workbook as a class text, an instructor's manual is available.

VIRGINIA B. GOULT
De Paul University

AUDUBON NATURE CAMP

The Audubon Nature Camp for Adult Leaders opens for its seventh season June 12 for five two-week sessions in 1942. Teachers, youth leaders, camp counsellors from all over the nation will gather to learn how plants and animals live and how to help boys and girls throughout the land appreciate, enjoy and protect the natural heritage of the American people.

The camp, located some 65 miles northeast of Portland, Maine, is in the Todd Wildlife Sanctuary, an island comprising 330 acres of climax spruce forest, at the head of Muscongus Bay. This forest, the interesting rocky, sandy and mud shores, the farms, open fields, hardwood forests, freshwater ponds and marshes of the adjacent mainland, seabird colonies on nearby and outlying islands, combine to form a fascinating outdoor laboratory. A daily program of field trips in these varied habitats affords campers opportunity to observe living plants and animals at first hand. Special emphasis is placed on the interrelationships between plants and animals and their dependence upon conditions of light, soil, water, weather as illustrated in the different types of environment visited. Practical suggestions for presenting nature study in schools, camps and clubs are stressed.

For illustrated folder and application blank, write to Box 5, National Audubon Society, 1006 Fifth Avenue, New York, N. Y.

FOSSIL FOOTPRINTS OF EXTINCT BEASTS FOUND IN KANSAS ROCKS

Footprints of animals more than a million years dead have been found in great numbers in a chalky rock deposit in Graham County, Kans., and are reported in *Science* by Dr. George F. Sternberg and Dr. George M. Robertson of Fort Hays Kansas State College. The tracks include those of camel, rhinoceros, mastodon, an unidentified carnivore, and numerous smaller animals.

The tracks were found in rock exposed in the spillway of a pasture pond. In the pre-Ice Age days when they were formed, the same spot seems to have been a water-hole visited by thirsty animals. Deeper in the rock, and belonging to a still earlier geologic period, were found remains of fish and turtles.

WORKSHOPS FOR JUNIOR COLLEGE INSTRUCTORS

With army officials warning educators to speed up training and to offer more short terminal courses to help the all-out war effort of the nation, the Commission on Junior College Terminal Education has decided to provide from coast to coast this summer three workshops for junior college instructors interested in setting up terminal courses and in studying other problems of terminal education. These workshops will be located on the east coast at Harvard University, in the midwest at the University of Chicago, and on the west coast at the University of California.

At least 100 scholarships will be provided for qualified junior college faculty members interested in study at the workshops.

This action was taken by the administrative committee of the Commission on Junior College Terminal Education which is a part of the American Association of Junior Colleges. Leland L. Medsker of the Chicago Public Schools, secretary of the committee, made the announcement this week. Rosco C. Ingalls, president of Los Angeles City College, California, is chairman of the committee, and Doak S. Campbell, president of Florida State College for Women, chairman of the commission.

The workshops at the University of California were started as an experiment last summer as part of the study on terminal education being carried on by the American Association of Junior Colleges through a grant from the General Education Board of New York. With 129 representatives of 97 junior colleges from 30 states taking advantage of this opportunity last summer and with definite progress made by them toward solving problems in terminal education, the committee has been encouraged not only to continue the workshops in California but also to establish the additional ones at Harvard and at the University of Chicago. The increased interest in terminal education in connection with the war effort this year adds even greater significance and responsibility to next summer's workshops.

AMERICAN ASSOCIATION OF JUNIOR COLLEGES

Junior college heads representing the nation's 650 two-year colleges shifted their annual meeting from Los Angeles February 28 to Baltimore, New Year's weekend in order to map out an immediate course of action for their institutions in wartime. They agreed that their first duty was to help win the war and pledged prompt cooperation to the government and all educational groups in order that "concerted action may prove valuable to the cause of victory and an intelligent humane after-the-war period."

Three days were devoted to sessions which discussed such wartime problems as curriculum adjustments, graduation without fulfillment of all requirements, selective service, guidance, air pilot training, civilian defense, and credit for military service. At one of the main sessions Colonel John N. Andrews of National Selective Service headquarters stressed greater student guidance during wartime, special training for young women to relieve men for active combat, provision for short terminal courses, and the desirability that young people stay in college until called for service.

The Association elected officers for 1942–43 as follows: President—John W. Harbeson, president of Pasadena Junior College, Pasadena, Calif.; Vice-president—Jesse P. Bogue, president of Green Mountain Junior College, Poultney, Vt.; Executive Secretary—Walter Crosby Eells, Washington, D. C.; other members of Executive Committee—James C. Miller, president of Christian College, Columbia, Mo., and James M. Ewing, president of Copiah-Lincoln Junior College, Wesson, Miss.